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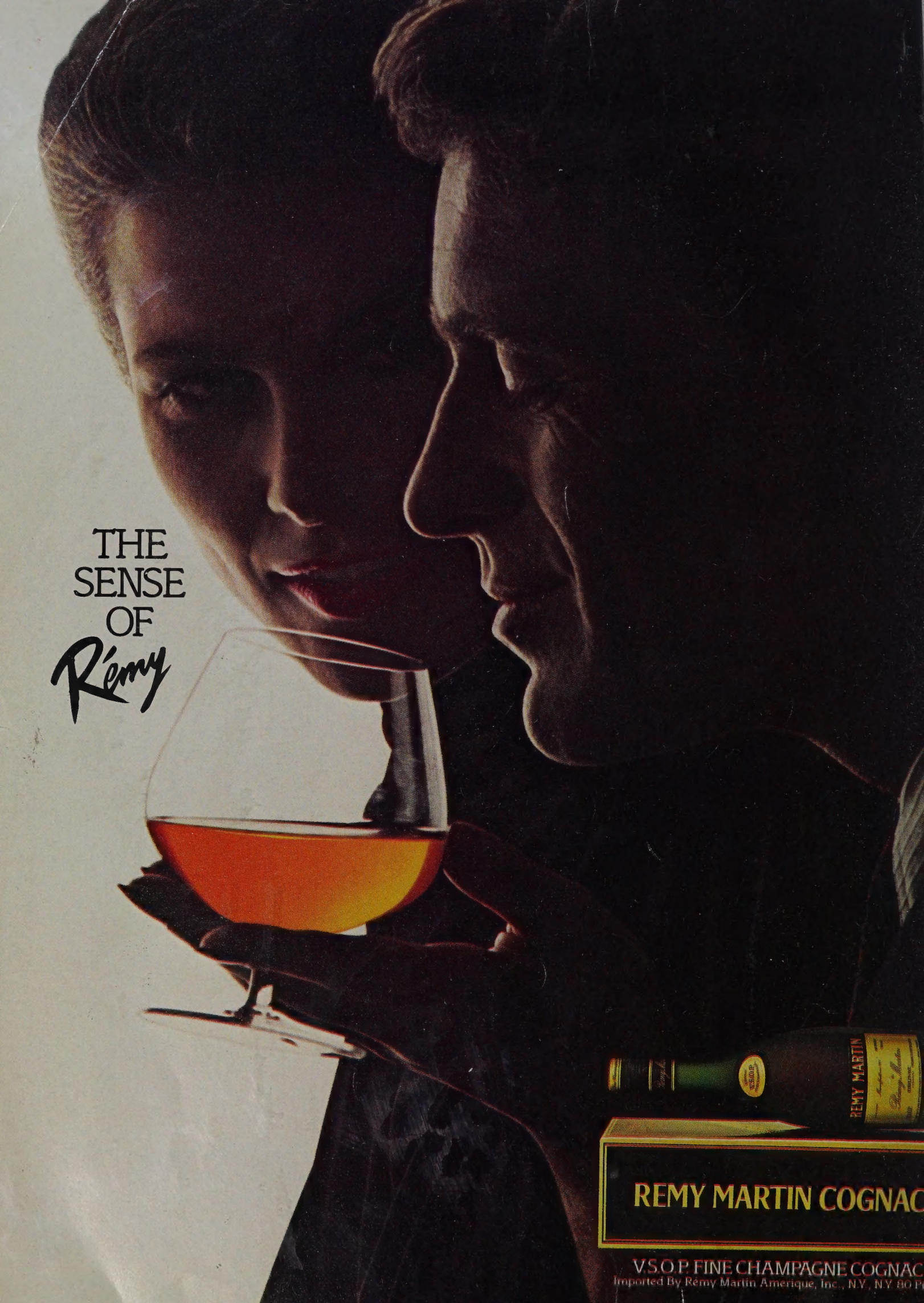
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NATURAL HISTORY

Vol. 94, No. 1, January 1985

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um of Natural History, Central Park
at 79th Street, New York, N.Y. 10024.
riptions: $18.00 a year. In Canada and all
countries: $23.00 a year. Second-class
ge paid at New York, N.Y. and at
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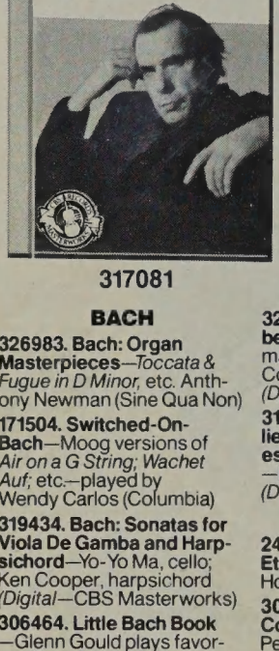

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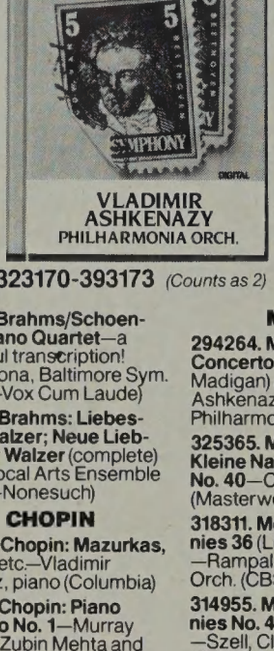

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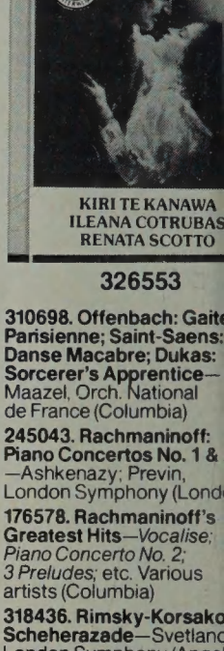

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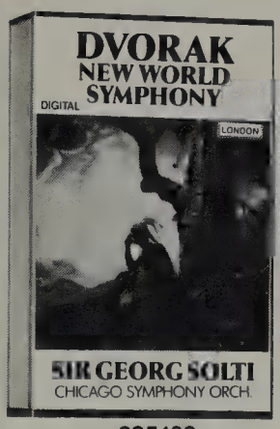

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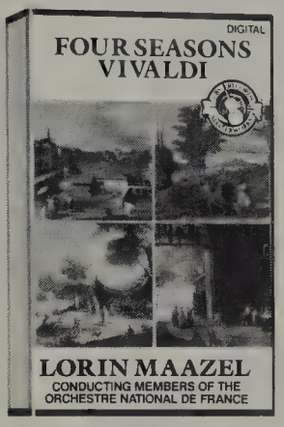

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Breaking Away

Even in its infancy, modern humanity displayed a talent for innovation

by Richard G. Klein

Nearly a century ago, archeologists working in Europe learned that the Neanderthals and their anatomically modern successors, the Cro-Magnons, made very different kinds of artifacts. The standard nomenclature reflects the distinction: Neanderthal artifacts are placed in the Middle Paleolithic cultural stage, while those of the Cro-Magnons are placed in the succeeding stage, called the Upper Paleolithic. The transition occurred between 40,000 (or perhaps before) and 35,000 years ago. Some specialists believe the Upper Paleolithic culture in Europe developed out of the local Middle Paleolithic, possibly at different times in different places; others argue that the Upper Paleolithic was an intrusive replacement. The issue is tied to the question of whether European Cro-Magnons evolved from local Neanderthals or whether they evolved somewhere else and then spread to Europe, displacing or, by interbreeding, absorbing the Neanderthal population.

Proponents of the idea that the Cro-Magnons and the Upper Paleolithic intruded into Europe have long pointed to evidence that both anatomically modern people and Upper Paleolithic culture appeared earlier in the Near East than in Europe. Recent discoveries in sub-Saharan Africa indicate that modern people may have appeared there even earlier. In addition, the African Middle Stone Age, broadly similar to what in Europe and the Near East is called the Middle Paleolithic, was replaced at least 35,000 or 40,000 years ago by the Later Stone Age, comparable in important ways to the Upper Paleolithic. To assess these major arguments, however, one must first understand the extent to which the two cultural stages differ.

At least three major points of contrast may be explored through archeology: the types of artifacts produced, the forms of environmental exploitation, and the size of human populations. To compare artifacts, archeologists analyze assemblages—the complete sets of artifacts found at different sites. The percentages of different types of tools in an assemblage, for example, may be more significant for characterizing or identifying a culture than the presence of one particular tool.

For Africa, the differences in artifact types are still being worked out, since few sites from the beginning of the Later Stone Age have been excavated and described. However, the differences are well established in Europe and the Near East. Middle Paleolithic assemblages tend to be dominated by stone flakes on which one or more edges have been retouched by chipping to form tools known as sidescrapers, points, denticulates, notches, and so forth. In contrast, Upper Paleolithic assemblages tend to contain a much higher proportion of elongated flakes, which archeologists call blades. These are frequently modified into tool types known as end scrapers and burins. End scrapers and burins have been found in Middle Paleolithic assemblages, but they are rare and are often less carefully made.

What is more striking is that Middle Paleolithic assemblages lack easily identifiable types of bone artifacts, which are present in the Upper Paleolithic. A similar contrast exists in Africa. And not until the Upper Paleolithic or Later Stone Age do items appear that can be unequivocally termed art objects and personal ornaments. The "invention" of art was perhaps tied to recognition that bone and related materials such as ivory, antler, and shell could be carved, polished, or otherwise shaped into myriad forms. These ma
als were the media for most of the ear
known art, although some artistic exp
sion is found in clay and on rock surfa
Perishable materials, such as wood
leather, were probably also used. Conc
ably, there were artists in preceding
who confined their work to perishable
terials; more likely, earlier people did
produce art as we know it.

Middle Paleolithic and Middle St
Age artifact assemblages also vary litt
space and over time. Contemporane
assemblages from regions as far apar
France and the Ukraine tend to con
basically the same artifact types, as do
semblages from separate parts of Afr
What variation there is can be largely
cribed to differences in local stone
material or in the precise activities car
on at different sites (for example, m
food preparation at one site, more we
working at another). Similarly, there is
tle indication of temporal change wit
the Middle Paleolithic or Middle St
Age—even assemblages separated
tens of thousands of years tend to be f
damentally alike.

In contrast, contemporaneous Up
Paleolithic or Later Stone Age artifact
semblages often differ markedly, e
when they come from neighboring
gions, and change through time is c
matic. These variations have led archeo
gists to recognize a multiplicity of Up
Paleolithic cultures, each with an aver
duration of only a few thousand years.
parently these peoples had an ability to
novate and to adapt to local circumstan
that was lacking in their predecessors.

Like those who came before them,
per Paleolithic and Later Stone Age p
ple made their living by hunting and ga

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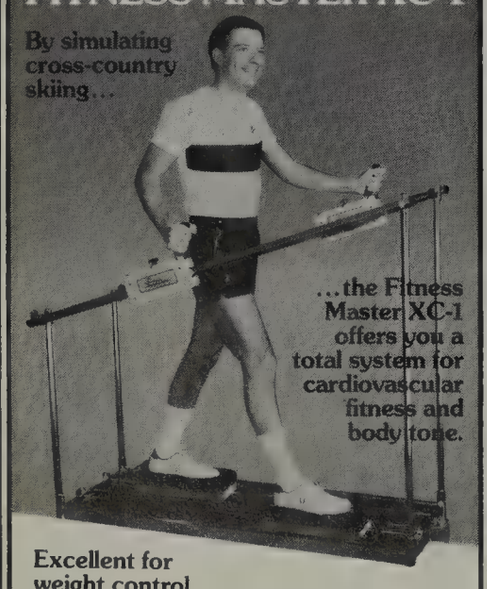
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ering wild resources, but they did so more effectively. The best evidence comes from the coast of southern Africa, where Later Stone Age sites contain abundant bones of flying sea birds and especially of fish, rarely found in earlier sites. The implication is that only Later Stone Age people could systematically obtain fish and fowl. Confirmation comes from fishing or fowling implements, including double-pointed bone splinters, which could have been baited to catch either birds or fish, and stone net sinkers. In general, Later Stone Age people exploited a higher proportion of all available animals, including such dangerous prey as wild pigs. Unlike their predecessors, these hunters had the bow and arrow and perhaps other weapons that allowed attack from a distance.

Two events that occurred at the very end of the Upper Paleolithic, 12,000 to 10,000 years ago, reinforce the idea that these later people differed from their predecessors in their capacity to exploit plant and animal resources. These occurrences were the extinction of a number of large mammal species on various continents and the beginning of plant and animal domestication, most evident in the Near East. Among the species that disappeared in Europe and Asia 12,000 to 10,000 years ago, the most prominent were the woolly mammoth and the woolly rhinoceros. About this time there was a global environmental/climatic change, marking the transition from the last glacial to the present interglacial. One result in Europe and Asia was that the area covered by forest increased at the expense of the open grassland favored by the mammoth and rhinoceros. While this change probably contributed to their extinction, both species had previously survived similar episodes. A reasonable inference is that more effective hunter-gatherers applied the *coup de grâce* to mammoth and rhinoceros populations already much reduced in numbers and distribution.

Similarly, Later Stone Age hunters, in combination with environmental change, probably caused the so-called giant buffalo, giant hartebeest, giant Cape horse, and other species to disappear from sub-Saharan Africa at approximately the same time. As in Europe and Asia, the extinct species had survived comparable environmental change during the Middle Stone Age and earlier times. Finally, people were probably partly responsible for the especially dramatic wave of large mammal extinctions that swept the Americas. The number of species involved was far greater than in the Old World, most likely because people were a relatively new element in American ecosystems.

The causes of plant and animal do tication remain controversial. I believ first steps represent a successful atte by some people to maintain a longstan relationship with animal and plant spe that were becoming rare as a result o matic change. Once again, Middle Pa lithic (and earlier) people experien similar environmental change did adapt in the same way, probably bec of their limited ability to innovate.

In Europe and Asia, as well as Af simultaneous gaps in the occupatio many sites within the same region sug periods of decline in human populati In Africa particularly, there is clear dence that human populations thinne over large areas several times betwee Middle and Later Stone Age and wi the Later Stone Age. The reason probably recurrent hyperaridity. Ne theless, Upper Paleolithic and L Stone Age people apparently were n numerous than earlier people living u similar environmental conditions. In p of Europe, more sites were occupied at any period in the past, and many larger and richer, suggesting that thi flects a genuine increase in human pop tions, not simply greater mobility f site to site. Sites with multiple dwell that may have been simultaneously o pied suggest that group size was la This may have been both a cause an fect of advances in hunting ability southern Africa, human population crease in the Later Stone Age is also cated by the smaller size of limpet s and tortoise bones that accumulate occupation sites, as would result fron creased exploitation of these resourc

Besides increasing their number long-occupied regions, Upper Paleol people also expanded into previously occupied areas, particularly northeast most Europe, northern Asia (Siberia) Americas, and probably Australia. main obstacle to earlier occupatio northeasternmost Europe and nort Asia was almost certainly the harsh and length of the winters, whether du glacial or interglacial periods. Upper leolithic adaptation to these extreme matic circumstances involved well- structed dwellings, tailored clothing, probably also advances in hunting, principal means of obtaining food.

The ruins found at many Upper Pa lithic sites indicate far more substa dwellings than any that can be infe from earlier sites. In addition, some n contain complex hearths designed to hance air flow and, thus, heat produc Tailored clothing is indicated by the ence of well-made bone needles and n

y by skeletons girdled with strings
ds in positions that suggest attach-
to close-fitting clothing. Some Up-
aleolithic sites also contain large
ers of wolf and fox paw bones, pre-
ly the vestiges of skins used for
warmth. There is no evidence that
le Paleolithic people sought or ob-
l fur-bearing animals on such a scale.
occupation of Siberia between
0 and 30,000 years ago was a precon-
of the colonization of the Americas,
cess made possible by a broad land
e that linked Siberia to Alaska dur-
Upper Paleolithic times. The land
e emerged because of the vast
nt of water taken from the sea by the
lacial ice sheets, especially the one
overed Canada from coast to coast.
ugh people may have reached
a at this time, the ice sheet probably
ed their passage south until the start
glaciation, about 14,000 years ago.
e first colonization of the Australian
ent, 30,000 years ago or somewhat
e, is interesting because Australia
hen, as now, separated from the
mainland by open water. During
r Paleolithic times, there may have
less water to cross, but there was al-
some. The first Australians must
fore have had boats, a further indica-
f the innovative ability of even the
st anatomically modern people.
comparison of Middle and Upper Pa-
ic gravesites gives evidence of other
al advances. Middle Paleolithic peo-
when they buried their dead at all,
d them in simple pits containing only
ody. Other items found in these
-almost always animal bones or stone
—may be "grave goods" or, more
, accidental contents of the fill. In
ast, Upper Paleolithic and Later
Age graves often contain art objects
er special artifacts that were deliber-
placed there, perhaps to reflect the
sed's social status or to ease the tran-
to an afterlife.
me Upper Paleolithic sites contain
cts made of stone from distances up
0 miles away or "luxury" materials,
as sea shells and amber, that had
more distant origins. These relatively
goods imply a web of social rela-
ips far wider than any that can be in-
d for earlier people. In sum, in every
tant respect that archeologists could
to observe, the cultures of Upper Pa-
ic and Later Stone Age people rep-
t a quantum advance over the Mid-
aleolithic.
ose who believe that the Upper Pa-
ic evolved locally in Europe, per-
several times, point mainly to sup-
posed similarities between local Middle and Upper Paleolithic artifacts. However, the similarities are far less striking than the differences, and they may be totally coincidental. Everywhere, the changeover appears to be abrupt, with one possible exception: the recent discovery, in France, of a Neanderthal in a very early Upper Paleolithic level. Before the skeletal remains came to light, however, some specialists had questioned whether the kind of artifacts involved were truly Upper (versus Middle) Paleolithic. I have suggested that they reflect contact between Middle and Upper Paleolithic people, before the former were displaced altogether.

The evidence that the Upper Paleolithic and Cro-Magnons intruded into Europe is more compelling. As already mentioned, fossils indicate modern people were already present in the Near East while Neanderthals occupied Europe. Interestingly, the earliest modern humans in the Near East made Middle Paleolithic tools, showing that biological change preceded cultural change. Then, sometime before 40,000 years ago, they began to manufacture Upper Paleolithic stone artifact types and bone points. These appear 40,000 years ago or before in southeastern Europe, but only about 35,000 years ago in western Europe, as we would expect if there had been a movement of Upper Paleolithic people from east to west.

Recently, it has been suggested that modern people appeared even earlier in Africa than in the Near East. Conceivably then, the earliest modern Near Easterners were themselves migrants from Africa. However, the African evidence requires confirmation with fresh, well-dated, more complete human fossils. We also need additional information on the culture of the early Later Stone Age, which appeared during a period when much of Africa was lightly populated because of widespread hyperaridity. Such a climatic crisis may have supplied the selection pressures behind the appearance of both modern people and the Later Stone Age.

Whenever and wherever the Upper Paleolithic or Later Stone Age first appeared, a broad relationship with anatomically modern people is well established. And the extraordinary differentiation in time and space that is a hallmark of the newer cultures and of subsequent history has occurred without any fundamental change in human biology. In contrast, cultural evolution and biological evolution appear to have gone hand in hand in earlier times, and at a painfully slow pace.

Richard E. Klein is a professor of anthropology at the University of Chicago.

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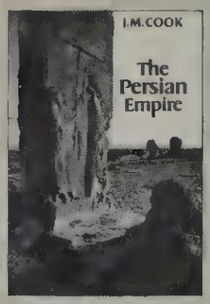

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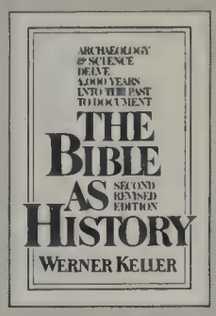
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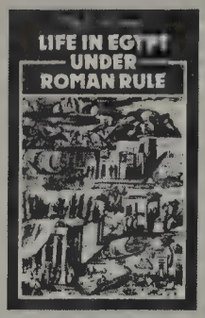

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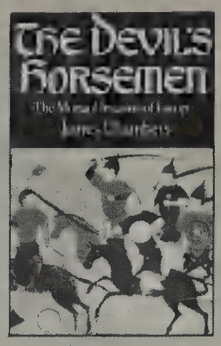

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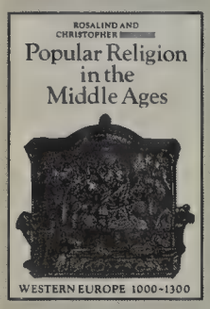

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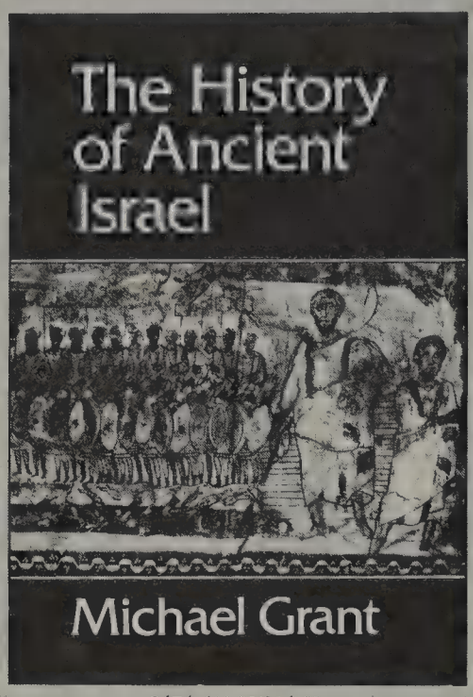

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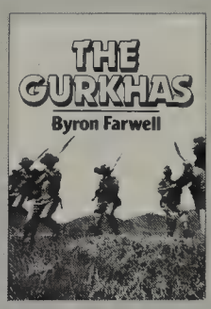

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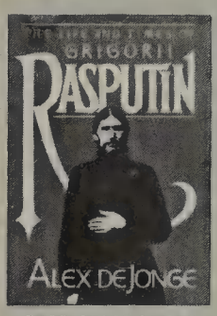

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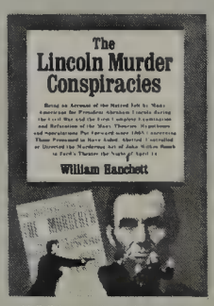

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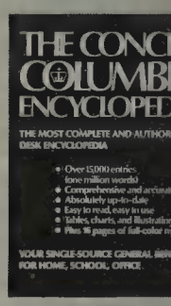

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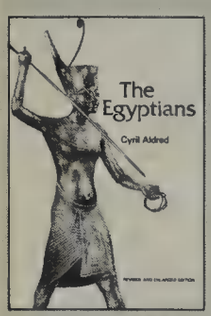

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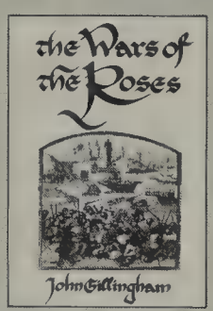

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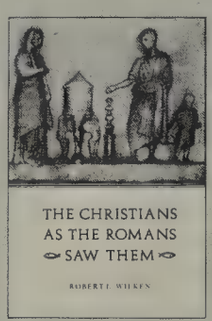

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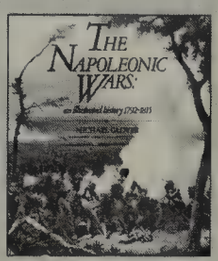

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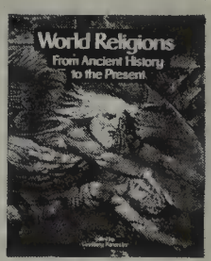

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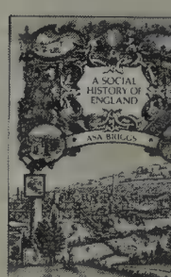

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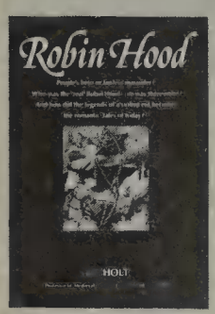

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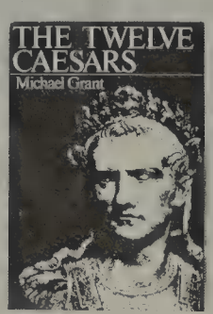

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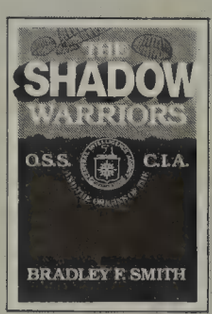

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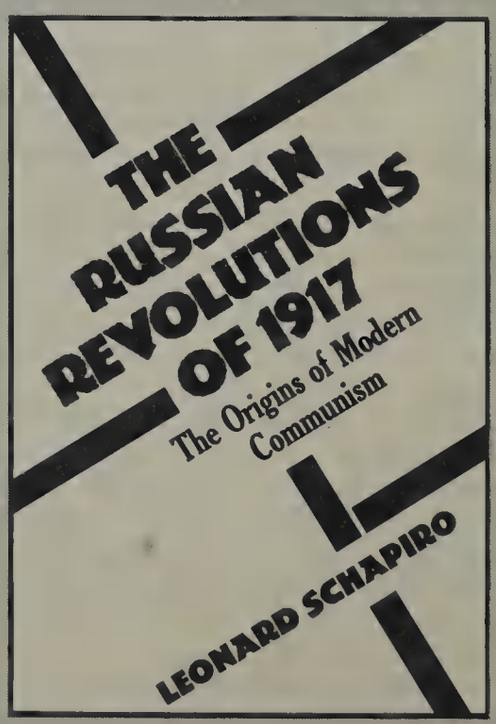

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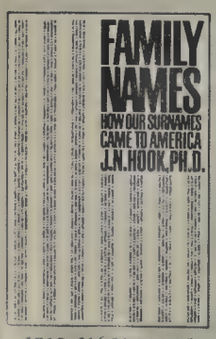

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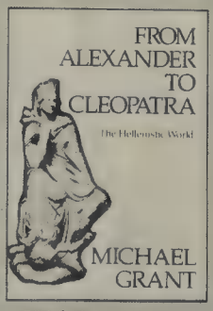

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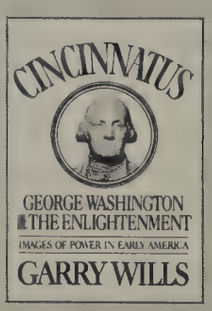

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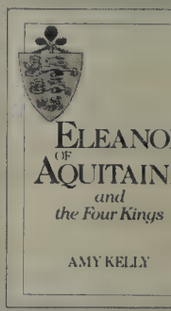

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"One Son Is No Sons"

Despite increased acceptance of sterilization and a lowered birthrate, India's massive population growth remains unchecked

by Stanley A. Freed and Ruth S. Freed

Devi and her five children were sitting in their village home in north India watching "Star Trek" on television. Caught up in the adventure, the children struggled to understand the English words. Their mother, meanwhile, was explaining why she was not interested in the government's program of birth control. Noting that her first four children had been girls, Devi said, "I would have gotten sterilized if I had had sons instead of daughters in the beginning. My six-year-old son is very weak physically, which is why I want to have one more son. Girls get married and leave the village to live with their husbands; they are no longer your own. A son in the family is necessary."

Already endowed with five children and intending to have at least one more, Devi and her husband contribute to making India a demographic giant second only to China. In 1981, India had 684 million inhabitants, about 15 percent of the globe's population. This figure includes 136 million persons added since the census of 1971, an increment larger than the total population of Brazil, which ranks sixth in the world. The current annual increase of about 15 million is more than double the population of New York City. India's population, now estimated at 735 million, will approach one billion by 2001 and may surpass China's soon after 2025.

Devi and her husband are not illiterate, poverty-stricken villagers, often thought to be at the heart of India's problem of massive population growth. Devi finished five years of school, and her husband is a high school graduate with a well-paying clerical job in Delhi and a sizable farm in a nearby village. The family is quite prosperous. What impels people like Devi and her husband to continue to have large families in an era of largely free, easily available contraception is that sons are the only dependable insurance against misfortune, poverty, and the disabilities of old age. The vast majority of Indians have no social security, private pension plans, or annuities; they rely instead on their sons. Few couples are satisfied with just one son, for the rate of infant mortality, while steadily declining, is still high enough to make parents with only one son very anxious. "One eye is no eyes, and one son is no sons," runs a popular saying. People try to have two or three sons, hoping that one of them will survive to care for them in their old age.

While a great deal of modernization has taken place in India since independence in 1947, the basic economic arrangements, values, and family roles, which tend to support the desire for a large family, have been generally stable. Even though India's birthrate has dropped and the use of contraception has mounted, India's average annual rate of population growth increased slightly from the 1960s to the 1970s—from 2.20 percent to 2.23 percent—because of lowered mortality. It is this stubbornly high rate of population growth—three times the estimated rate for the United States in 1981—that the government of India is fighting to control. As the late Prime Minister Indira Gandhi was fond of saying, India adds an Australia a year to her population.

In 1951, the year of the first Indian census after independence, the size of the population was of sufficient concern to lead to a national program of family planning, but it was presented in terms of maternal and child health care rather than fertility control. Serious efforts to reduce fertility did not begin until the mid-1960s. The endeavor to check population gro was most intense during the polit Emergency legally proclaimed by Pr Minister Gandhi on June 25, 1975, aft period of political unrest and dema that she resign. During the 21-month riod of the Emergency, which lasted u March 21, 1977, couples were stron urged—by publicity, plus a combina of cash payments and various disincen measures—to undergo sterilization. governmental slogan "Two or three c dren, enough!" was widely dissemina Because the program was often percei as coercive, the ruling Congress Party fered a temporary electoral defeat. spite the popular reaction against the cesses of the Emergency, however, government of India did succeed, m faster than might otherwise have h pened, in establishing sterilization a routine and acceptable option for cou wishing to terminate childbearing.

Today sterilization is the principal c traceptive technique used in India. cause it permanently ends childbear parents do not use it until they have all children they want or think they will ne The present government, concerned v fertility control, extols and publicizes small family of two or three children. dian parents think in terms of two sons one daughter as the ideal "small" fam but in trying for at least two sons they up with an average of about 4.2 child In general, the minority of Indian par who choose to be sterilized do so about children too late from the governme point of view, and the large majority s sterilization altogether, wanting to be v sure that they will never be left withou least one son. "To be sterilized is to ten fate" summarizes a common attitude

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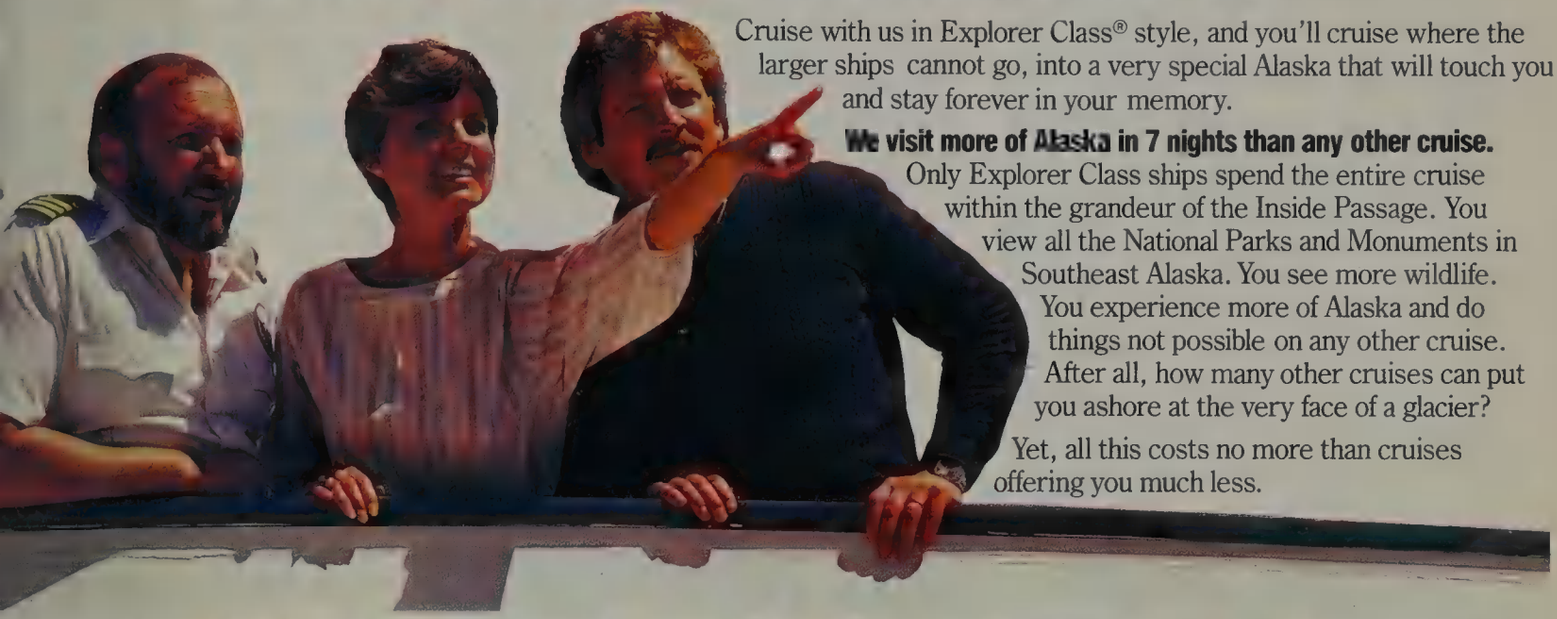

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The government would like to achieve a family norm of two children by the turn of the century, at which point India's population would begin to stabilize, reaching a plateau of 1.2 billion by the middle of the twenty-first century. Is this goal realistic? The answer must be sought chiefly in India's villages, where 76 percent of the population lives. At various times during the 25-year period from 1958 to 1983, we have had the opportunity to investigate population growth in a north Indian village we call Shanti Nagar (the name is fictitious). The study is of particular interest because it encompasses the demographic watershed between the time that family planning barely existed and the period when fertility control became a serious governmental concern and sterilization was established as the major contraceptive technique. Although one should be cautious about drawing conclusions from a single village, the study of a small community such as Shanti Nagar provides an appreciation of the motives and attitudes that underlie people's everyday decisions about childbearing, family size, and sterilization.

Shanti Nagar is typical of the region that includes the northern states of Punjab, Haryana, western Uttar Pradesh, and the Union Territory of Delhi. From the 1950s to the 1980s, Shanti Nagar has undergone an economic revolution. The village has acquired electricity, brick houses have replaced mud houses, and streets have been paved. In agriculture, bullock power and hand labor have largely given way to machinery. Paved roads and increased bus service make it easier to commute to urban areas, where many men have jobs. Radios are now commonplace, there are some TV sets, and newspapers are delivered daily. The educational level has risen dramatically for both men and women. The village has become more prosperous and better informed about government programs.

Although one would expect that the modernization of education, communications, and the economy would significantly alter family life, the village family has generally maintained its traditional form and functions. A single Indian family may include more people than just a couple and their children: often a family is composed of a couple, their married son (or sons), and his wife and children. Sometimes two or more married brothers live as members of the same family, the eldest brother acting as family head. Families are relatively large by American standards, consisting on average of more than seven members. Men are young when they marry, and women are very young, often beginning their married lives shortly after first menstruation. Men continue to live at their parental home after marriage and bring their brides to live with them. Women are expected to begin childbearing as soon as possible, for both the economic and political strength of a family and a woman's own status depend on the number of sons. "Marriage is not for pleasure," say the villagers. "It is the duty of a wife to have children."

Because attitudes in the 1950s were so strongly in favor of having a goodly number of children, we would have given family planning and, particularly, sterilization little chance of making significant headway. Therefore, when we returned to Shanti Nagar in 1978 after an absence of twenty years, we were startled to hear so many people discussing their own sterilizations or those of their neighbors. We eventually found that there were 68 sterilizations involving both males and females, tantamount to 26 percent of the women of childbearing age (15 to 45 years) at the time. By late 1983, there were 93 sterilized individuals.

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Sterilization has run an uneven course in Shanti Nagar. It was accepted slowly at first. From 1968 to 1974, 3.4 individuals on the average were sterilized annually. Then came the twenty-one months of the Emergency, which began in 1975, and the average number of persons who underwent sterilization jumped to about 20 per year. After the Emergency, the figure returned almost to the pre-Emergency norm: from 1977 to late 1983, 4.7 persons were sterilized per year. The big jump in sterilizations during the Emergency was due to the strong campaign mounted by the government. Governmental pressure was especially effective with men holding government jobs. Most of the men sterilized during the Emergency were in government service.

When the Emergency ended, there was a noteworthy change in the proportion of men to women undergoing sterilization. Prior to 1977, 53 percent of the operations were performed on men; for the period from 1977 to late 1983, this figure had fallen to 15 percent. The shift is probably related to the introduction of the surgical technique of laparoscopy, which has r female sterilization easier. The go ment also suggested a somewhat h payment to women undergoing ster tion, compared with the incentive to Moreover, villagers may not have bee tirely convinced that vasectomy was proof. If a vasectomy is done improp a pregnancy can follow, exposing the fortunate woman to suspicion of adul and to village gossip and scorn. Why that chance when a tubectomy will a the problem?

Most of those in Shanti Nagar who cussed reasons for not being sterilize for postponing the operation cited a sufficient number of sons. On the o hand, the expense of raising children overwhelmingly the main reason tha lagers gave for undergoing steriliza Couples also frequently cited the gov mental sterilization campaign, princi its coercive aspects, as a motive for b sterilized, and a few people menti that sterilization was seen as the solu to specific health problems of wome

The emphasis on economic reason cuses attention on the changing valu child labor. In rural India, where chil participate on the family farm fron early age, the value of their labor rem considerable. However, the moder tion of agriculture has reduced the for child labor. At the same time, t has been an increase in employ opportunities that require an educati qualification. Many parents aspire to ter jobs for their children and p fewer, more educated children to mor merous, uneducated offspring. Few afford to educate all the children that can possibly have.

The findings from Shanti Nagar gest that a significant drop in the gr rate of the population cannot be expe in the near term. The parents in Sh Nagar who chose sterilization did so erally after having four or five living dren, and it must be borne in mind most couples have not been steril Overall, completed families in the 1 were larger than those of the 1950s eraging 5.2 versus 5.0 living child Even the women who were sterilize whose husbands were sterilized) in had almost as many living children (a erage of 4.9) as had the women with pleted families in 1958, almost al whom used no contraception.

On the other hand, persons who a pate at least a slight downturn in the of population growth can find grounds for optimism in the statistics Shanti Nagar. In 1978, sterilized mot had fewer living children than

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sterilized mothers who had com
their childbearing (4.9 versus 5.5
average). Moreover, the effect of ste
tion is becoming more pronounced
the end of the Emergency in 1977 un
in 1983, couples underwent sterilizat
a younger age and had fewer childre
before 1977. But they still average
living children, enough to produ
rather high rate of population grow

A startling consequence of the ste
tion program is its effect on the prop
of males and females in Shanti N
population. In 1958, for every 100 fe
there were 104 males; about twenty
later, there were 111 males. Son
tribute such a preponderance of ma
the suspected mistreatment of f
children. They are said to be relative
prived of such necessities as food, a
tice perhaps deriving partly from po
Because the village was more prosp
in the late 1970s than in the 1950s,
pected to find a more equal balan
males and females. That, on the con
the proportion of males had substan
increased was a surprise. The rea
clearly the practice of sterilization,
offers couples some opportunity fo
trolling the sex of their children. The
schedule the operation after having
sired number of sons, regardless o
number of daughters.

Sterilized couples had, on the ave
about three sons and two daughters
imbalance is no accident: couples ai
between two and three sons before u
going sterilization, but almost no on
perately wants to have more than
daughter. This sexual imbalance al
pears to be increasing. From 1977 to
sterilized couples averaged twice as
sons as daughters. It requires no
foresight to see that the further spre
sterilization could lead eventually
noteworthy shortage of women.

From an American and Western
pean perspective, one might assume
population control could be achiev
India by instituting a system of soc
curity, such as is found in the U
States, to reduce the need for so
sons and make the two-child family
ble for many couples. In developed
tries, much of the economic suppor
care of the aged comes from outsid
family; children may assume minor
cial and custodial roles or none at all
feature of Western society is not of
origin: it appeared in England, for
ple, several centuries before the Indu
Revolution, the source of sustenance
ing through the centuries from the
and the guild to the parish and to the
But India is a different world, whe

nd support of the aged have always a family affair. Indians do not be- that the government or anyone but sons will take care of them when they ld. Their experience is that govern- s and policies change too frequently trustworthy in the long term. A fam- ith fewer than two sons makes no to most Indians. This attitude would t even if the resources to institute a m of social security could be found. any Western analysts also assume economic development to improve tandard of living will solve the prob- f population growth in India. How- there is no evidence from Shanti r or elsewhere in India that motiva- o limit family size to two or three ren develops after a certain economic s has been attained. Even the effect e education of women—perhaps the promising of the socioeconomic fac- hought to lower fertility—is some- ambiguous in India and, in any case, ttle impact until women achieve the ge level and begin to work outside the . In all probability, it will be a long before a significant proportion of ru- dian females are sent to college. though sterilization is increasing in and the birthrate has been declining me time, these developments do not ge an imminent solution to the prob- f India's population growth. For our we would be inclined to keep a sharp n the average size of completed fam- for this statistic will provide greater nt into India's demographic future the drop of a few points in the birth- If parity at completed childbearing s signs of stabilizing at between four ive children, India will continue to p to its reputation as a demographic rnaut. In that case, India's currently tary program of family planning t have to be replaced by more Draco- measures, like those instituted in a. The Indian government fell from when it previously tried to intro- a stringent program of fertility con- The challenge is to try to control lation growth in a democracy where ies of four or more children are, for good reasons, considered necessary.

ley A. Freed is a curator and Ruth S. d is a research associate in the Amer- Museum's Department of An- ology. This article is based on the rs' study, "Fertility, Sterilization, Population Growth in Shanti Nagar, : A Longitudinal Ethnographic Ap- ch," to be published in 1985 in The ropological Papers of the American eum of Natural History.

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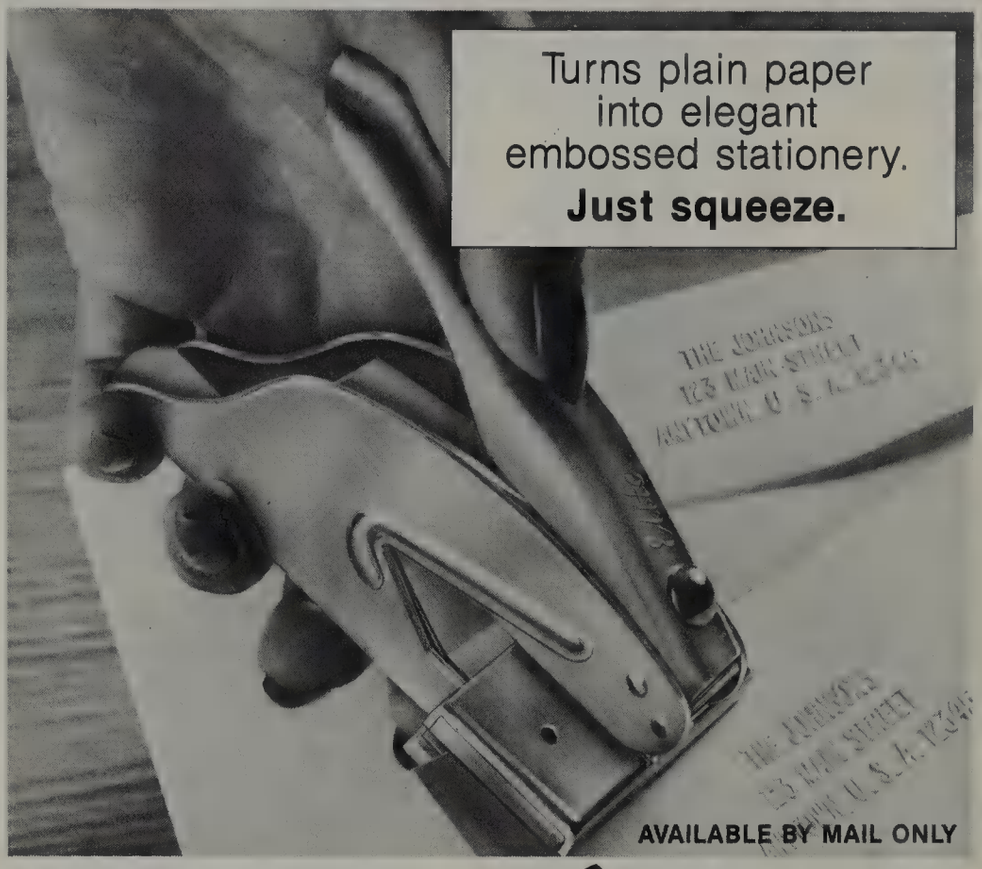

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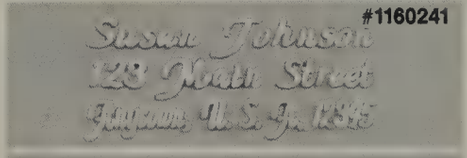

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The Sinister and the Trivial

"We meet the world in many styles, all worthy of attention"

by Stephen Jay Gould

When the old curator of entomology died many years ago, his successor went through his rooms and cabinets, cleaning and sorting to start the new regime afresh (improbable as this anecdote will seem, I know two people who swear that it is true and that they were there). He opened one drawer and found a box designated "pieces of string for future use." Next to it, chock-full of items so identified, lay another container labeled "pieces of string not worth saving."

We note, in this tale, the stereotype of the professional taxonomist—calm, unpretentious, orderly to a fault, and unrelentingly dull. His task, the allocation of nature's diversity into appropriate pigeonholes and the composition of descriptive catalogs to order and access the inhabitants of the holes. Yet the debates of taxonomists are among the most spirited and acrimonious in science. I can't print (even in this liberal journal) half of what I heard in the great wars recently mounted against traditional systematics—first, by numerical taxonomy; more recently, by cladism. These vitriolic debates may only reflect an inverse relationship between importance and intensity—the essence of our concept of pettiness. Yet I prefer to think that they accurately reflect the vitality and excitement of a gutsy profession saddled with an image both unfair and untrue.

This essay describes two tiny taxonomic debates, separated by a century, seemingly unrelated and apparently unimportant in two senses. First, they treat biological variation at the lowest level of differences within a species. Second, they have been expunged from the record of memory for all but a very few specialists—"forgotten even by God," as Browning wrote. They also embody two concepts despised and rejected by decent folks (but providing a handle for my title). First, *aberrancy* as recorded in reversed, or left-handed, coiling of some peculiar snails. These oddballs are technically called sinistral, as opposed to ordinary right-handed, or dextral, snails. The predominance of right-handedness in another species is, of course, the chauvinistic source of our words *sinister* and *dexterous*. Second, *insignificance* as reflected in a debate about how taxonomists should name biological variation at its lowest recognized level of subspecies. (The etymology is, again, curiously appropriate. The second part of a species' designation—the *sapiens* in *Homo sapiens*, for example—is called, technically, its trivial name. The debate about subspecies rested upon a proposal that geographic races be recognized by adding another trivial term to make the full name a trinomial—for example, *Homo sapiens sapiens* for modern humans and *Homo sapiens neanderthalensis* for a famous extinct race. *Trivial* has its vernacular meaning of "irrelevance" and its technical sense, which spurred the debate about subspecies described later in this essay. Its etymology refers to the town gathering spot where three roads meet, hence commonplace. Three roads in the etymology; three names in the taxonomic debate.)

Both small tales also embody, I think, an important lesson about the impact of evolutionary theory and the nature of scientific discovery.

Although Aristotle had denied the possible existence of southpaws among snails, occasional lefties in dextral species had long been prized as curiosities. (A snail shell is a tube closed at its top, or apex, and open at its bottom, or aperture. The tube winds around and down an axis of coi
By convention, a dextral snail opens it
erture to the right of the axis when
hold it face to face; a sinistral snail w
the other way and opens its aperture t
left of its axis.)

For aficionados of snails—I am o
the distribution of sinistral coiling is
odd and mysterious. No one has ever
posed an even vaguely plausible argu
for why either dextral or sinistral co
should offer an advantage. Indeed,
other coiled creatures seem to go rig
left with equal facility. But snails hav
jured this ambivalence and have v
with their foot in an overwhelming
the vast majority are dextral. To be su
few groups are entirely sinistral, and s
species within otherwise dextral gr
have opted for left deviation (usually
ing for their apostasy with an imp
badge of their dubious distinction, a
Busycon perversum, the lightning co
But, within most species, sinistral s
are either unknown or surpassingly
occurring at frequencies of one in
dreds to one in millions. In my own fa
ite creature, the West Indian land
Cerion, exactly six sinistral individ
have been found (one by me). And I d
even want to think about how many zi
Cerion have passed before the inspe
of scientists. C.J. Maynard, greatest
onologist of them all, found three s
trals among an estimated 300,000 sn

We may regard the late eighteenth
tury as the great, or heroic, age of des
tive taxonomy. Linnaeus had codified
modern system of binomial nomencla
in 1758. A network of collectors follo
armies and missionaries into all corne
the earth and sent back hundreds of
recorded species to the private cabi

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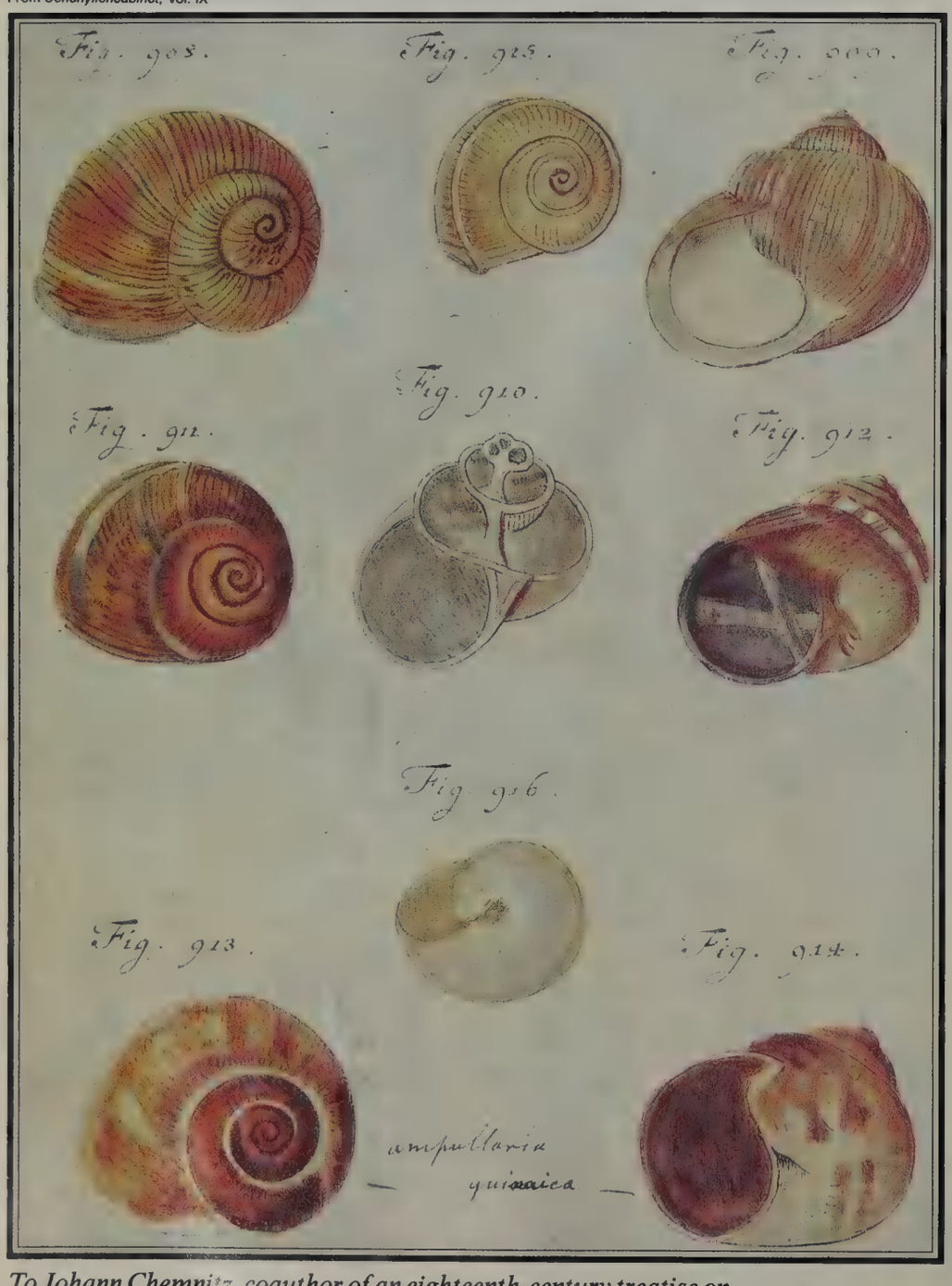
and embryonic museums of Europe. These new creatures were often described in beautiful monographs with exquisite hand-colored plates. Taxonomy was a science in the forefront of thought and aesthetics.

The shells of mollusks are among the loveliest of natural objects. One work stands out for beauty and inclusiveness among eighteenth-century treatises on mollusks—the many-volumed *Conchyliencabinet* (shell collection) of Martini and Chemnitz, two dedicated amateurs who combined careers as physician and preacher with a passionate avocation for shells. Most volumes are compendia of descriptions, species by species, group by conventional group. But volume nine, written by Chemnitz, is organized by concept to discuss a puzzle. It bears one of those glorious old titles that tells you more than you want to know about the contents—*Linksschnecken oder von den verkehrtgewundenen Conchylien, welche gegen die Gewohnheit aller übrigen ihre Mundöffnungen nicht auf der rechten, sondern auf der linken Seite haben, Mit 14 nach der Natur gemahlten und durch lebendige Farben erleuchteten Kupfertafeln* (Left-handed Snails, or inversely wound Shells, which contrary to the Custom of all others, have their Apertures not on the right, but on the left Side, With 14 Copper Plates drawn from Nature and illuminated with natural Colors).

(May I succumb to temptation and float a gratuitous and tangential comment that, I hope, will be read in the intended spirit and not merely as an exercise in vanity and egotism—though I freely confess to both sins. Chemnitz's *Linksschnecken* is one of the most gorgeous books that I have ever had the pleasure to read. T plates are stunning, the typography e gant, the paper thick, textured, a unyellowed by age. But the text is in G man [in the old Gothic script] with lo quotations in Latin. It is therefore clos to nearly all American readers, given c lamentable training in languages. I lo languages and have spent a great deal time learning several. Many colleagu may view this passion as an arcane intere of no particular use in science, a bit of l eral learning to be indulged for perso idiosyncrasy. The personal reasons a sufficient and knowledge need never justified by utility. But I can read Che nitz and they can't, and the ten hours spent with him last week was the best tir I've had in months. All knowledge is us ful. It always "comes round again" li the tune on Arlo Guthrie's guitar. A you never know when.)

From *Conchyliencabinet*, Vol. IX



To Johann Chemnitz, coauthor of an eighteenth-century treatise on mollusks, these leftward-coiling escargots were "errors of nature."

Johann Hieronymus Chemnitz h been forgotten. His name does not ev appear in the sixteen-volume historia bible, the *Dictionary of Scientific Biogr phy*. His treatise on *Linksschnecken* even more obscure, unknown to most pr fessionals. Yet it contains the descripti of an interesting and revealing experime among its pretty pictures and descri tions.

Chemnitz's *Linksschnecken* is writt in a relaxed, almost garrulous style nc unknown in our age of spare and uni spired scientific prose. He begins with effusive dedication to Crown Prince Fre erick of Prussia. Although I suspect th Fred had other fish to fry and little time bother with left-coiling snails, Chemni laid both his volume and specimens "mc respectfully at the feet" of his sovereig He explains that he spent twenty yea scouring all corners and boundari (*Ecken und Enden* in the more euphor ous German original) of the conchologic world, slowly assembling by "costly cc respondence" Europe's finest collection *Linksschnecken*. "And therefore," wrote, "I hope with this volume to provi a welcome gift to all warm friends shells" (who, no doubt, cared a good de more than the crown prince). He then lis and praises the many amateurs and afici nados who helped him *mit Rat und T* (neither gunfire nor rodents, but "advi and action").

Chemnitz decided to concentrate on th subject closest at hand—the occasion lefties found among large and convenie samples of the edible escargot *Hel pomatia*. In his time, these peculiar shel long prized by collectors (who, I trust, a their cake before having the wrappin posed a problem to the prevailing vie

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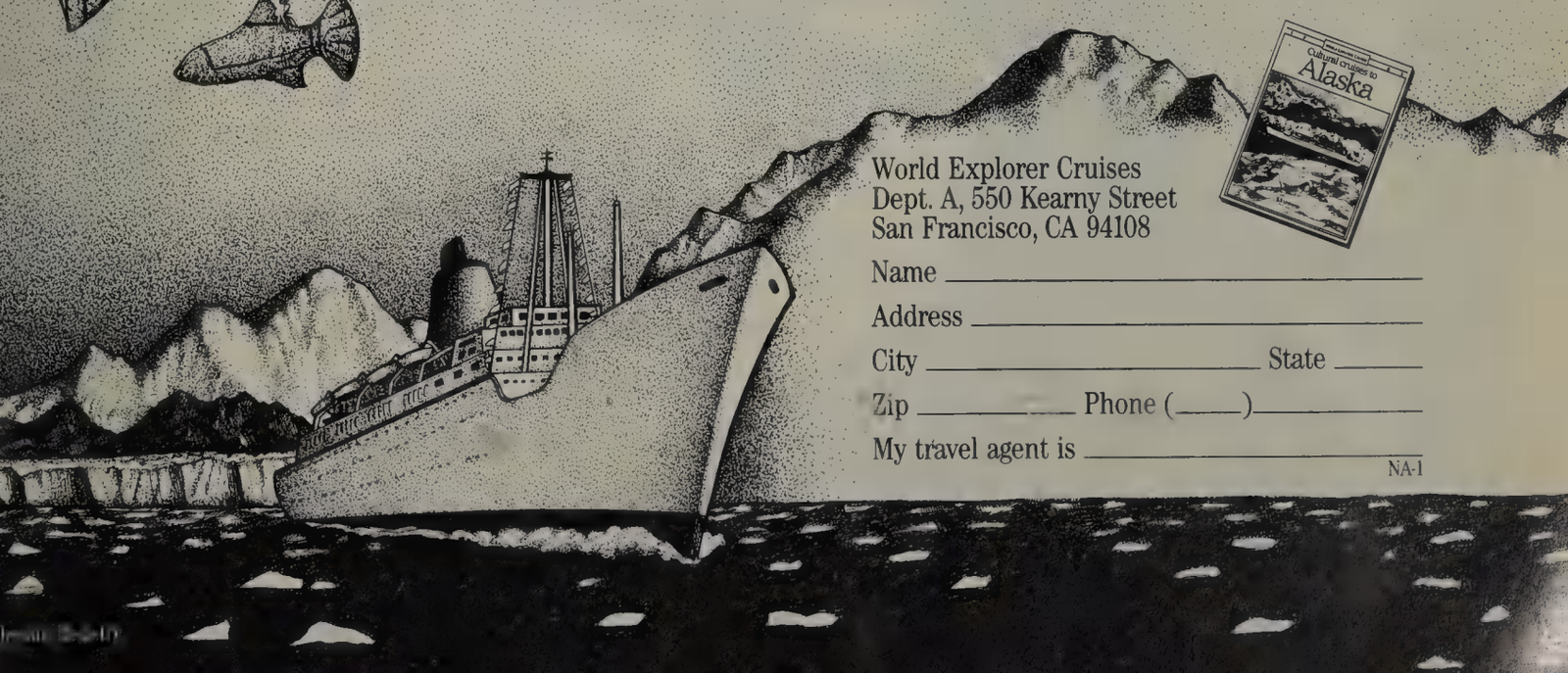

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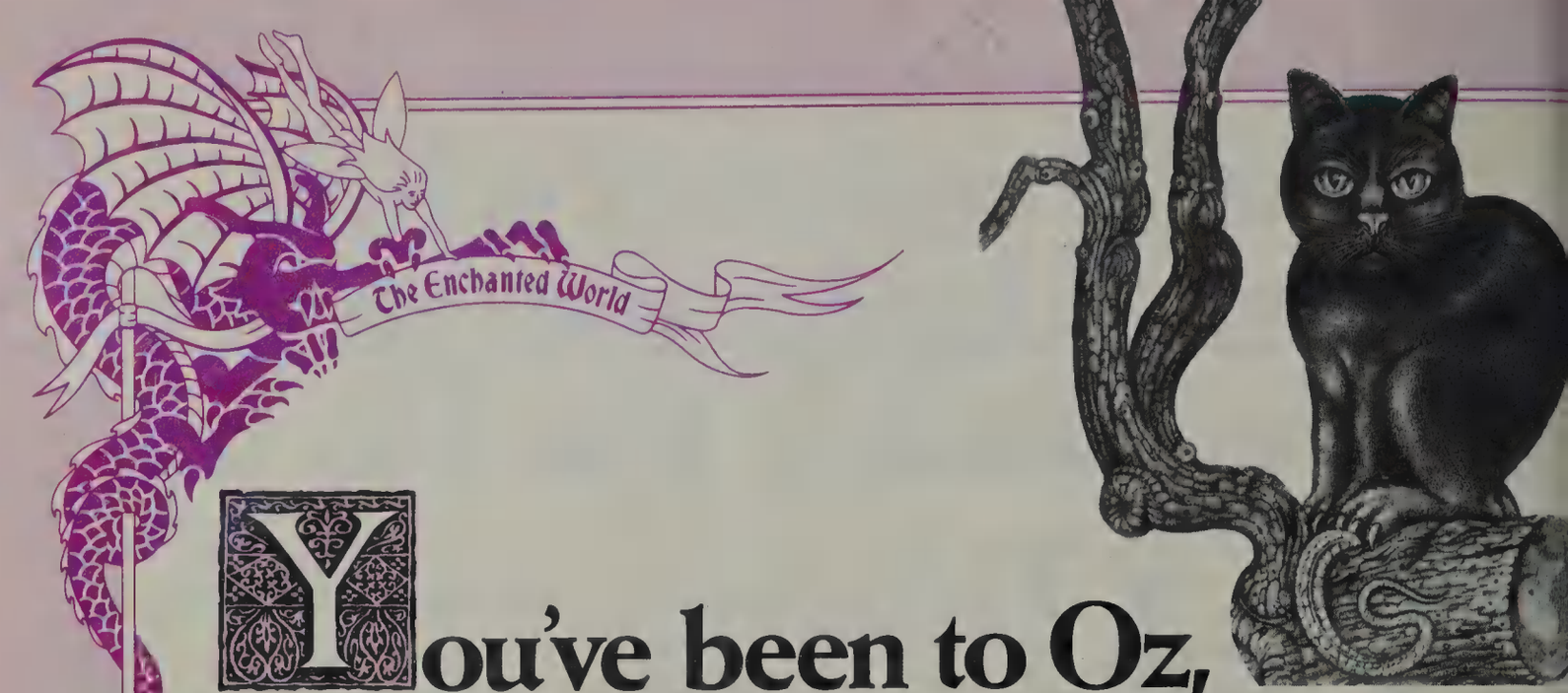

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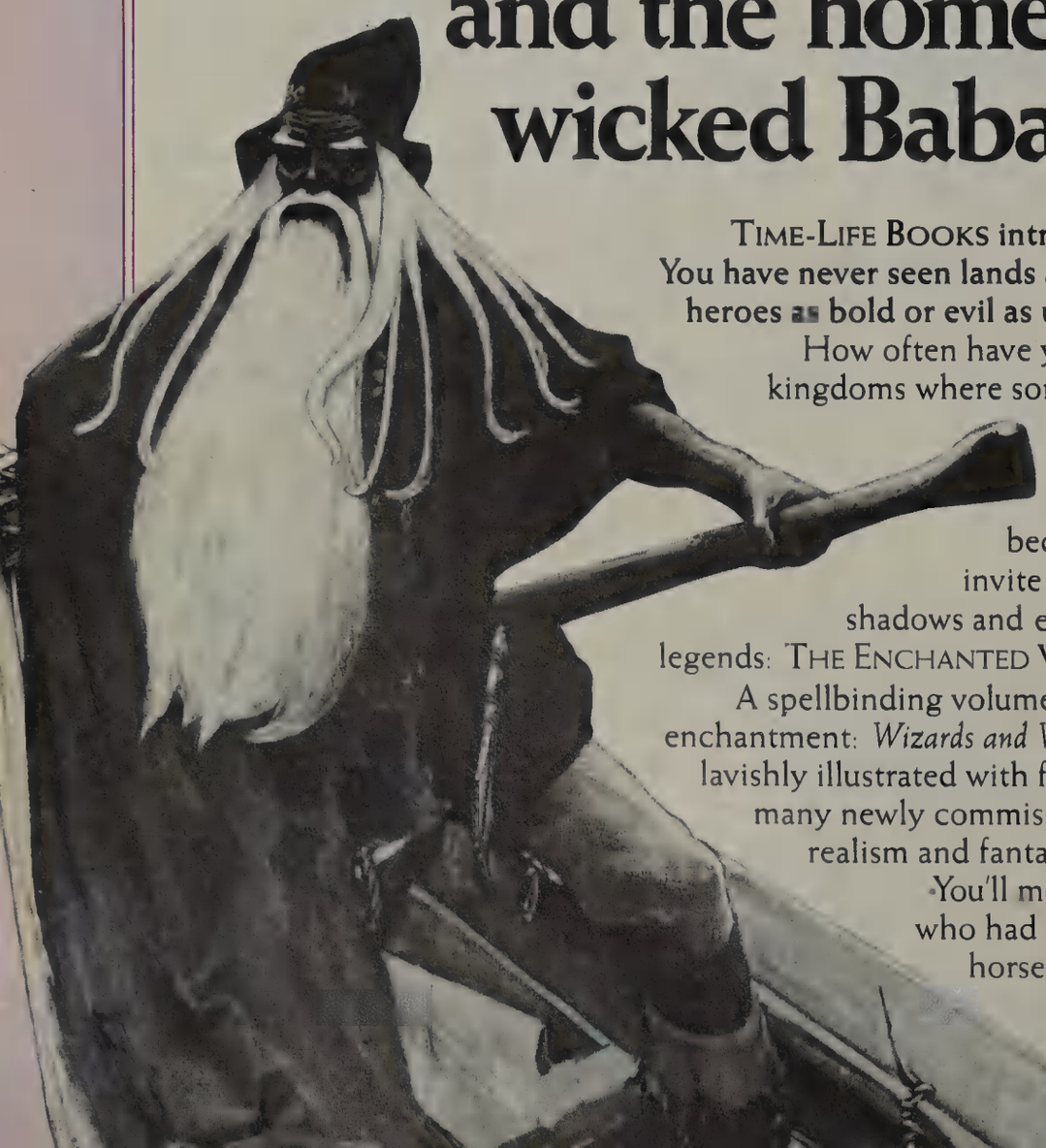

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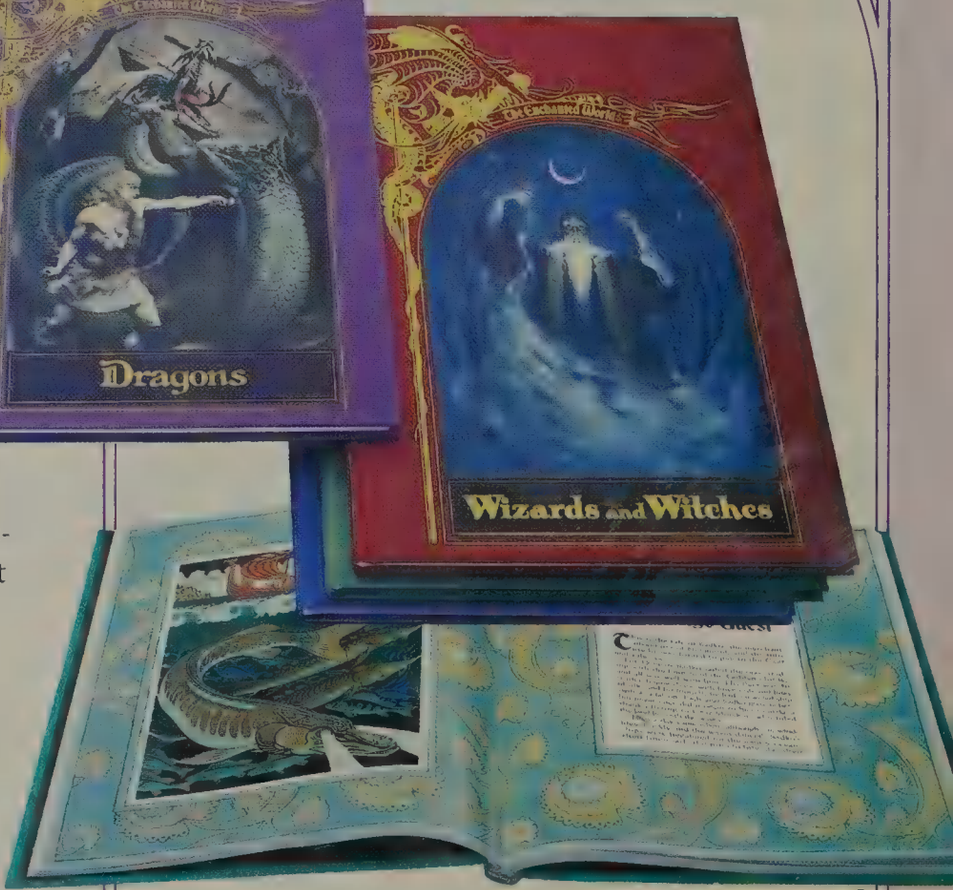

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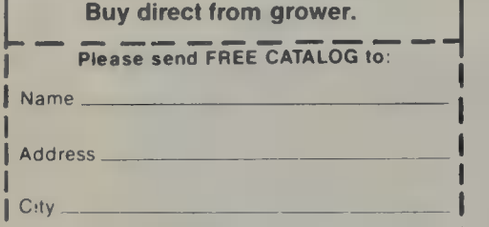

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of species and the stability of nature.

Three years before the fall of the Bastille, and more than seventy before Darwin, species were regarded as stable entities, related not by evolution and descent but as incarnated ideas of God's mind and, therefore, as expressions of cosmic order and harmony. If each species represents a single divine idea, then it possesses an ideal form, or type. The organisms of a species vary, but their differences are accidental or imperfect departures from the abstract essence—an expression of the sad fact that tangible physical objects can never be perfect representations of ideal prototypes. (This approach to variation—viewing differences among individuals as degraded departures from an ideal form—is called "essentialism" since the ideal and unattainable type is the essence of a species.)

Darwin's revolution is often depicted as a substitution of change for immutable stability. But it accomplished so much more. It also turned the study of variation absolutely topsy-turvy—and variation among organisms is (to use that awful neologism) the "data base" of systematics. To Darwinian evolutionists, variation is intrinsic and irreducible—the "real stuff" of nature. Variation among individuals within a species is also the raw material of future evolutionary change. To essentialists, variation is troubling and irrelevant; the more organisms vary, the more the ideal form will be hidden and obscured. What essentialists tried to eliminate as an accidental overlay, evolutionists cherish as essential.

We cannot understand why *Linksschnecken* were so troubling to Chemnitz unless we grasp this fundamental difference. We look at sinistral oddballs today and our fascination is unambiguous—for we experience the gut appeal of their peculiarity, while we regard their differences from ordinary dextrals as entirely friendly and informative, as part of the variation that defines nature and drives evolution. Chemnitz experienced the gut fascination, but everything else about a sinistral snail could only threaten an essentialist. A bit shorter or taller, a bit darker or lighter can be viewed as minor departures of little importance, but reversed coiling seriously blurs an essence. Thus, Chemnitz did not devote a volume to *Linksschnecken* only because oddballs are intriguing; they represented a threat to his world view.

Chemnitz developed a preferred, a priori solution that he proceeded to test. Perhaps the rare sinistral *Helix pomatia*—they occurred at frequencies of one in several thousand in European markets—were not intolerable departures from essence of escargot. Perhaps they really members of a rare and separate cies (not a hopelessly ad hoc prop since Chemnitz had documented sev exclusively sinistral species in his wi wide survey of *Linksschnecken*). If s tral escargots were a separate spe then they would produce left-han progeny when mated. Chemnitz there scoured the food markets of Europe, g ered several small groups of live sini escargots, proceeded to breed them, anxiously awaited the results (and mean "with anxiety," not "eagerly").

Several attempts failed as his sinis fell victim to heat, drought, predatio possible mixture with errant righties nally, he succeeded as his sinistrals m and laid eggs. But expectation, in case, only bred disappointment, for hi bies hatched as a veritable army of Jo Maggios and Tom Seavers. Righties not a lefty among them. He wrote: "T from pure sinistral snails, and agains my wishes and all my presupposit pure dextral snails descended."

Chemnitz used the documents of profession to rue his results, citing in ness Psalm 58:8—"Like a snail w melteth, let every one of them pass a . . . " But he could not deny the conclu and it troubled his essentialist convict deeply: "They are not a new spe . . . They are errors of nature . . . dege ated from their species, afflicted chil of rightborn, rightturned, rightwound ents and grandparents."

Chemnitz's work is from another a so many ways, and its very archa might teach us the potential transi and contingency of our own cherished victions. Chemnitz's essentialism m its difference in substance, but the v tion in style is even more striking. Mo mythology about the "scientific meth requires that we keep desire and expe tion out of our experiments; we are posed to test like objective automata to derive our ideas and theories dire from data obtained with an open and c blank mind. But how can passionate opinionated human beings so behave why should they? What we do requir basic intellectual honesty and respec nature, is rigorous fairness in proce and continuous challenge to prefer and expectation. But how can we sc nize our prejudices if we don't examir acknowledge them? We serve the cau objectivity better by recognizing our subjectivity and guarding against it, by pretending that it doesn't exist.

Chemnitz, unconstrained both by r ern myths and the economics of pub

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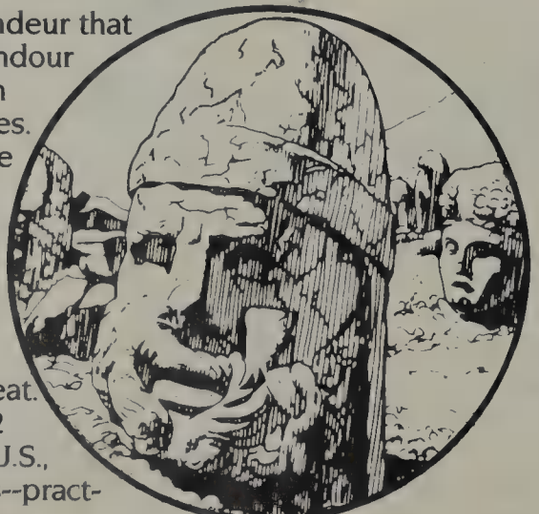

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ing, wrote at great and charming leng
his hopes and his disappointments.
don't wish to claim that his age was h
and passionate, ours phony and hear
If we err toward denying the human
of science, Chemnitz can come da
ously close to denying the constrai
empirical reality. In a remarkable
sage, best expressing the difference
tween his time and ours, he writes
surprising result: "Since this really
truly happened, it absolutely must be
sible." Absurd as this statement soun
a modern empiricist, we must recog
the different view that it expresses a
the relationship between experim
fact (a mere occurrence involving
dental departures from essences)
deeper, necessary "reality."

Yet this different view of reality m
Chemnitz's conclusion all the more
mirable. He wanted to establish sini
escargots as a different species in ord
preserve purer essences. If he rega
empirical reality as nonconclusive
might have wriggled out of his disco
that sinistral escargots begat dextral
dren—and that they must therefor
odd variants within a dextral species.
he did not. He repeated his experimen
ways hoping for a different result. W
he could not obtain his desired end
calmly accepted nature's message
concluded with simple eloquence: "
happy that I have seen and learne
much"—a fitting conclusion to one
and forgotten story about biology's
gest question, the meaning of change
variation. Score one against essentia

Chemnitz published the last volum
his *Conchyliencabinet* in 1795. One le
of a long lease later, in 1894, the se
Lord Rothschild—a most improb
candidate for such a role—launched
other famous series of taxonomic pub
tions and began another battle agains
sentialism. Darwin's evolutionary
had triumphed, and the old man hin
had been resting in Westminster Ab
for a decade. But essentialism had
died with him, although its ideolog
buttress had disappeared. A world of
ference may separate the acceptance
idea and its full conversion into prac
We often live in a peculiar intellec
schizophrenia, acknowledging a new
of nature but continuing to use and e
the comforts of the old.

Walter Rothschild, titular head of
great Jewish banking family, was on
the richest and most powerful men in
land. The Balfour Declaration of 1
promising British support for a Jew
state in Palestine, was presented neithe
an act of Parliament nor a public p

ɔn, but as a letter addressed to Wal-
thschild. Yet Rothschild both ab-
ublic power and dispensed private
: in order to pursue his true love—
llection and classification of ani-
Since he commanded more re-
s than most national museums, he
ed to accumulate the largest collec-
rimarily of birds and butterflies)
ssembled by a single person. More
00 collectors scoured the globe for
ending their discoveries to his pri-
useum at Tring.

nschild combined his energy with
ise as a prolific, publishing, first-
xonomist. He established as cura-
Tring two of Europe's finest sys-
sts—E. Hartert and K. Jordan. In
he founded a journal, *Novitates*
gicae, to publish the taxonomic re-
f research on his collections. By
forty volumes, with 23,000 pages
0 plates, had appeared. In 1895, ex-
00 years after Chemnitz published
al volume, the Tring trio (Walter
s curators) formally adopted the tri-
l system for their journal and cast a
ful vote for a new idea then convuls-
e sober science of systematics. Lord
child wrote:

he earliest historical period every in-
ɔn in philosophy, physics, mechanics,
ɔmy, locomotion, medicine, surgery,
in every branch of human intellec-
material progress, has been fought
ɔposed tooth and nail by those who
ɔeen brought up in the schools of
nt of the previous epochs. Neverthe-
e have always ended up by adopting
nnovations. So I feel sure it will be
zoologists, when once they have
d the meaning of the trinomial no-
ature as applied to geographic races.

why should a debate about naming
ch passion? We need look no further
Homo sapiens to recognize that sin-
ecies often display a great deal of or-
variation. If species spread them-
over large geographic areas and
ranges of topography and climate,
ccidents of history (who gets there
and requirements of adaptation
traits confer advantages in local
nments) will lead to the evolution of
ble geographic races—many spe-
or example, are larger and lighter at
atitudes and smaller and darker in
oist tropics.

naeus's original system was bino-
Each species has but a single name
ɔsed of two parts: its generic name
o in our case) and its trivial name
ns, meaning "wise"—no rule of no-
lature decrees that the etymology be
priate). The binomial system pro-
vides no formal mechanism for naming geographic variation within a species; all humans are simply *Homo sapiens*.

Trinomialism, first advocated as a formal system by American ornithologists in the 1880s, recognized geographic races by adding a third term to the traditional binomial name. At first, most traditional taxonomists hated the trinomial system with all their heart. They had spent a lifetime learning binomial names and mastering a satisfying system for nature's plan. Now some upstarts wanted to go through everything all again, adding third names to parse well-defined species into a plethora of subcategories. Chaos would reign in the profession most committed to order.

But the debate involved far more than convenience, thus defining its interest for us. For the bitter arguments about trinomials record one more skirmish in the continuing retreat of essentialism. Evolutionary theory had forced geographic variation out from under the essentialist rug. Pre-Darwinians had felt no strong need to name geographic races because they only embodied the irrelevant or threatening variation that diluted essences and made

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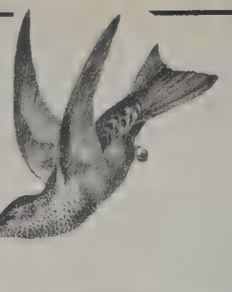

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life difficult for scientists committed to defining the ideal forms of God's incarnated ideas. This rationale had been lost by Rothschild's time, but the essentialist desire to view each species as an idealized entity, not as an irreducible cloud of variation, persisted. If trinomialism prevailed, then what was a species anyway? No geographic race could claim primacy of place (or form); all are equal, and a species, therefore, has no essential being, only a set of variations. Chemnitz's experiment (and hundreds like it) forced an acknowledgment of wide variation within species, but perhaps an essence still lay hidden amidst the expanded range. But if species are ordered as series of geographic races, how can any one form be more basic than any other?

Evolution implies the irreducibility of variation at all levels, but views that have comforted us since Plato die hard. Tring's trio began as a small ensemble crying in the wilderness, but trinomialism eventually prevailed, primarily because its underlying philosophy harmonized with evolutionary theory. Ironically perhaps, trinomialism enjoyed only a brief reign and then fell victim to the very movement that had assured its success. We have dropped trinomials again because we have found better ways to express, primarily in graphic and numerical terms, the irreducible geographic variation that defines species and denies them any essential form. Lord Rothschild won his bitter battle, but the names he cherished are slowly fading from use (damned slowly, as indicated by the irate letters this passage will surely elicit from zealous compilers with precious life lists of observed subspecies).

I learned history in school as the story of kings and generals. But armies (and nations) move on their stomachs (snails do too, by the way); no Napoleon can prevail if his quartermaster doesn't deliver the chow. Many academic historians are now trying to recapture the everyday life of peasants, laborers, and shopkeepers, for (perhaps paradoxically) the most dramatic expression of changing contexts must surely be their impact upon routines that regulate our ordinary activity. Yet these activities often become invisible with the passage of time because no one records, in any formal way, what plain folks do all the time.

Our usual approach to the history of ideas suffers from the same myopia of confinement to the movers and shakers of theory. Historians have scrutinized every day of Darwin's life; they have traced in intimate detail the public debates that surrounded biology's greatest revolution. We are assured that Darwin did not arise in a vacuum, that his way had been m straight by social and scientific chan that produced a more receptive world. are also told that his success required sustained effort of innumerable partisa But the foot soldiers of his revolution invisible, their work buried in dusty jo nals on the back shelves of libraries or dustier labels attached to specimens in "storage facilities" of our major museu An army of taxonomists made the croo straight and the rough places plain— they have been forgotten.

I am not saying, in the old positivist dition, that the likes of Chemnitz Rothschild made Darwin by patiently cumulating the facts of nature until t formed a chorus that could not be den Fact and theory form an unbreakable of interaction. One thousand Chemnit establishing ten thousand new facts ab natural variation, paved Darwin's but the grade had been surveyed changes in theory and social cont Chemnitz could ask the right questi and accept the answers that he himself veloped, in part because the late ei teenth century had already become a genial time for theories of dyna change.

But we do obtain a peculiarly skew and discontinuous view of history when view great thinkers as exclusive agent scientific change. Chemnitz and Ro schild pursued their work with the sa dedication, passion, and honest eff they too deserve our respect and at tion—not only for reasons of human s darity, but also in our quest to underst history.

Fractal curves have recently beco popular in mathematics. Such curves oversimplify greatly, maintain their f at all scales. If they are roughly co gated at a grand sweep of miles, they not be smooth over millimeters, but jus bumpy at a properly reduced sc (Coastlines may record a fractal tern—the rocky coast of Maine may be more jagged than the path around s grains along a foot of beach.) Perhaps speak metaphorically, intellectual deba are like fractals—not smooth and u spiring because small in scope, but ful sharp edges and pungency at all sca each piece a model of the whole. In case, as Milton said, we meet the worl many styles, all worthy of attention. So may "post o'er land and ocean with rest," but "they also serve who only st and wait."

Stephen Jay Gould teaches biology, g ogy, and the history of science at Harv University.

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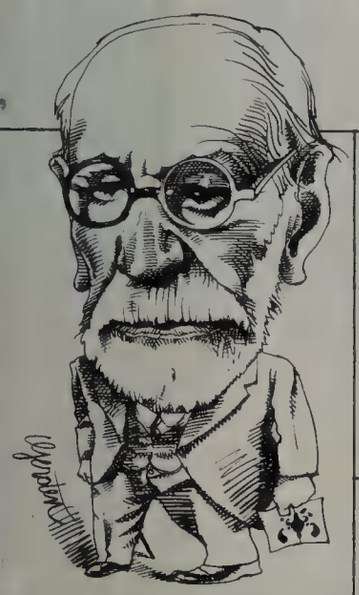

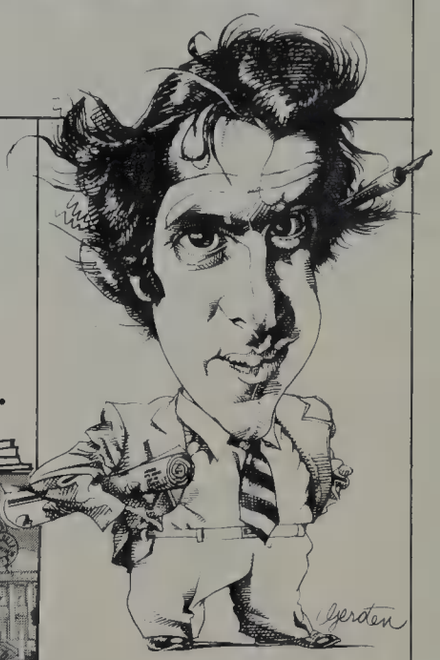

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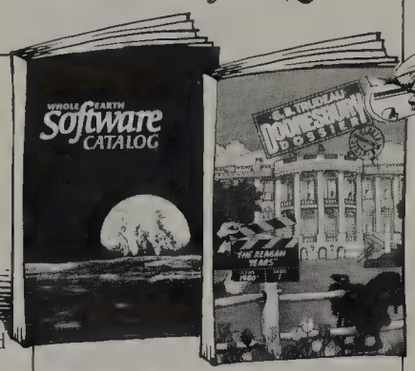

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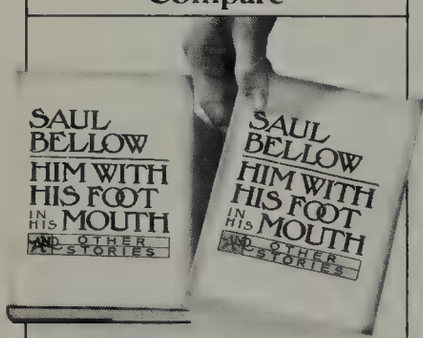

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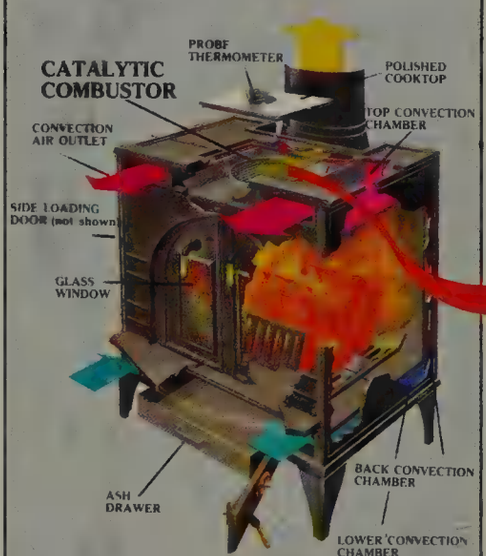

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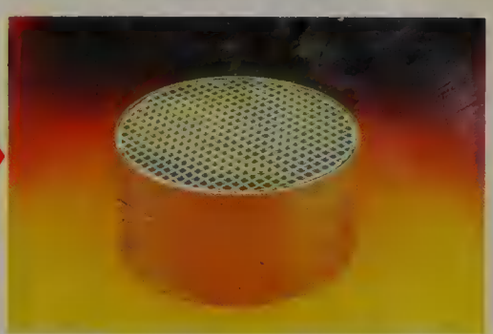

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The Glowing Avalanche

The collections at the American Museum of Natural History contain a number of odds and ends that are probably of greater historical than scientific value. One of the most curious—and, in its way, saddest—collections is buried in the storerooms of the Department of Mineral Sciences. Gathered about the turn of the century by Edmund O. Hovey, the curator of the Museum's mineral collection, it consists of a twisted and partly fused street sign in French, several melted bottles, a melted pewter tankard, and an assortment of "bread-crust" volcanic bombs, ash samples, charred wood, and other bits and pieces.

Hovey gathered these at the site of one of the most devastating volcanic disasters of modern times—the eruption, on May 8, 1902, of Mount Pelée, on the island of Martinique, which resulted in the annihilation of the city of Saint Pierre and the death of its 30,000 inhabitants. When the news of the eruption (and that of the previous day's eruption of Soufrière on the adjacent island of Saint Vincent) reached New York on May 9, Museum president Morris K. Jesup immediately called a meeting of the trustees, and they decided to send the scholarly, bespectacled Hovey to the scene of the disaster to make a firsthand report, take photographs, and gather a collection. Five days later, Hovey boarded the *Dixie*, a United States relief ship carrying food and medicine to the surviving islanders. An expert volcanologist, Hovey knew the dangers of the expedition. Volcanoes almost never erupt once; the initial explosion is almost always followed by even more violent eruptions, mud slides, and earthquakes.

The *Dixie* arrived at Martinique on May 21. A second explosion had rocked the island just the day before, and from aboard ship Hovey could see the vast cloud of steam and ash, punctuated by lightning, hovering over the northern end of the island.

Letters, newspaper stories, and accounts of survivors have given us a vivid picture of the events that preceded the eruption. There had been many signs that the volcano was about to explode.

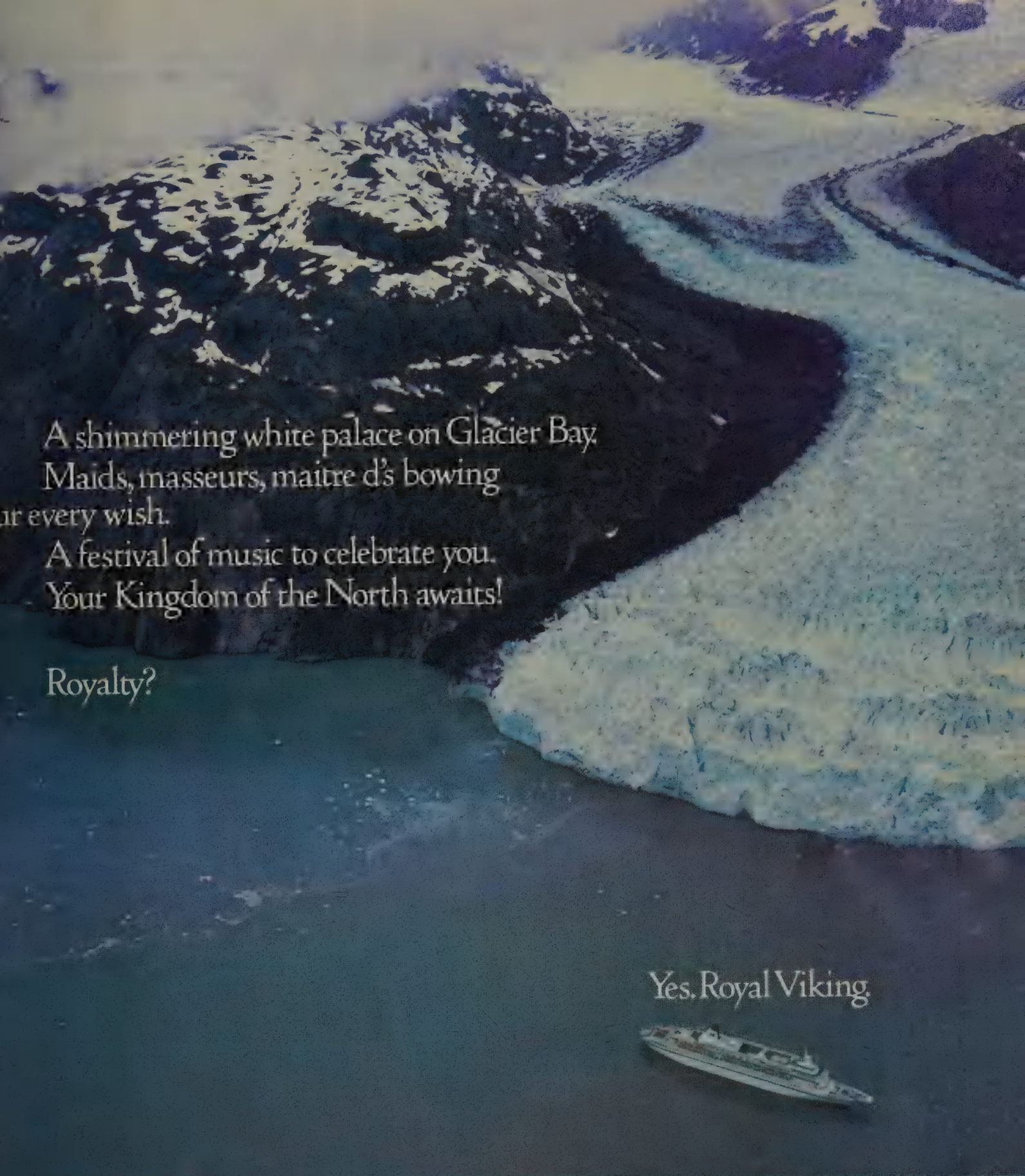
A year before, a picnic party to the summit of Mount Pelée had discovered a small fumarole, or vent; noxious gases and steam emanating from it had killed the adjacent foliage. A month before the eruption, three loud explosions had rocked Saint Pierre, and the volcano began to smoke. On April 25, two weeks before the disaster, a great black cloud issued from the mountain; in a few days, the fumes and ashes had become so thick that many of the inhabitants of the city could not go outside without covering their faces with wet cloths.

By May 1, the rivers that flowed off the mountain started to rise, and people noticed a number of dead fish being carried along by the current. On May 2, a series of small eruptions dropped a layer of ash on the city. This was followed by a larger eruption and a mud flow that swept down the mountain, carrying huge boulders and uprooting trees. On the evening of May 3, as the volcano belched forth a great cloud of ash, the residents of the city could see great flashes of light and hear almost continuous thunder on the mountain. Birds, apparently felled by poisonous gases, began dropping out of the sky. Quietly, like falling snow, an inch of warm ash blanketed the city.

The first human tragedy occurred on May 5, when a torrential mud slide cascaded off the mountain and swept people to their death before roaring the sea. Minutes afterward, the sea it slowly subsided for a distance of yards, and then just as slowly returned undating the city's sea walls and jet Electricity failed, but it made little dif ence; the city was illuminated by a con ual lightning display, accompanied sheets of flame and thunder from the cano itself. One by one the seven under ter telegraph cables connecting the isl with the outside world went dead. On evening of the seventh, the number eruptions increased, and people be fleeing the city. In a tragically sh sighted effort to stem the panic, French Governor at Fort-de-France clared that the danger would not incre and sent soldiers into the city to prev officials from leaving. To underscore point, both he and his wife went to S Pierre.

At about 7:50 on the morning of eighth, a ship called the *Roraima* was tering the port of Saint Pierre. An e neer was standing on deck, looking at mountain, and he later described the ing eruption. First, he said, a big clou black ash shot out of the top of the cano. Immediately afterward, a sec puff of ash burst from one of the slo This cloud, dense and brownish bla didn't rise as the other had, but settled the slope of the mountain and rus downward toward the city, gathe speed as it went. Surging and rollin great heaving waves, it spread over city. The engineer, seeing the cloud rac toward his ship, took refuge in the eng room, while a friend remaining on d was killed instantly.

A second witness, observing from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top of a nearby rise, said that as the cloud blanketed the city, "there was a blinding flash of fire, and in a moment the whole beautiful city was in flames. The flame seemed to travel like lightning over the city from north to south; but it was not lightning. It looked as if the black cloud from the mountain had been ignited as soon as it reached the city." Within three minutes, the black cloud had incinerated Saint Pierre and killed about 30,000 people. The only survivor was a man named Samson Cil-Barice, who was imprisoned in the Saint Pierre jail at the time. Badly burned, he later described to Hovey how hot sand had spilled through the windows of his cell during the avalanche. The cloud was what volcanologists call *nuée ardente*, or "glowing avalanche," a mixture of incandescent ash, superheated steam, and noxious gases spewed out by certain types of volcanoes. A *nuée ardente* may reach temperatures in the thousands of degrees and will instantly ignite anything it comes in contact with. Cushioned by expanding gas and steam, a *nuée ardente*, once ejected, may race down the side of a volcano at speeds of more than 100 miles an hour. It is probably the most deadly of all volcanic phenomena. The entire city of Saint Pierre literally burned to the ground in a matter of minutes.

On nearby Saint Vincent, Soufrière had erupted the day before, killing 1,500 people and destroying one-third of the island. Most of the people on Saint Vincent were killed by a wall of boiling mud, five stories high, created when the crater's large, blue lake was heaved out by the eruption.

These were the scenes of devastation that Hovey encountered when he arrived at the islands on May 21. He spent his first two days surveying and photographing the ruins of Saint Pierre and talking to some of the witnesses. He especially wanted to make first-hand observations of the topography of the two volcanoes themselves, and his first chance to do this was on Saint Vincent, where the volcano had temporarily abated. He arrived at Saint Vincent on May 23 and on May 31 decided to climb the summit of Soufrière. Accompanied several other geologists, Hovey ascended the hardened mud and ash flows and finally reached the crater rim. From the crater, a huge abyss with a boiling mud pool at the bottom, rose a giant plume of steam and ash. With a thunderous noise tremendous avalanches of rock and ash periodically cascaded down the crater's inner slopes.

The initial explosion, Hovey observed, had knocked down the trees over most of the mountain in a pattern radiating outward from the crater, and their roots had been charred and carved into fantastic shapes "as if they had been subjected to the action of a powerful sand-blast." Hovey collected samples of "bread-crust" bombs (hardened pieces of lava thrown out by the volcano) and took photographs of the desolate scene.

When Hovey returned to Martinique in early June, Pelée was still erupting. Nevertheless, he was determined to climb

At the American Museum

The Last Sailors

The January members' program will explore the vanishing world of seafaring and boatbuilding. Neil Hollander will lecture and show his film, *The Final Days of Working Sail*, narrated by Orson Welles. Hollander spent two years traveling aboard a 32-foot sailboat, meeting sailors from countries as diverse as Brazil, India, and Indonesia. The program is free and open only to members. It will take place on Tuesday, January 15, at 7:30 P.M. in the Auditorium and advance tickets are required. For more information call the Membership Office at (212) 873-1327.

Circles and Starbursts

The January family program for members features *Circles and Starbursts*, a participatory theater experience that demonstrates the hidden workings of planet Earth. Using storytelling, movement, audience participation, and a grab bag filled with treats for children, the program teaches children, ages four to eight, about the atmosphere, rainstorms, the seasons, and more. Three programs will be repeated on Sunday, January 20, at 11:00 A.M., and 1:00 and 3:00 P.M. The program is free and open only to members. Advance tickets are required; please contact the Membership Office at (212) 873-1327 for additional information.

Naturemax Theater

New York's largest indoor screen, the four-story screen of the Museum's spectacular Naturemax Theater, will feature two films in January: the long-running *To Fly!* and the lush *Living Planet*. Members are still entitled to discount tickets for daily showings in the Naturemax Theater. For information about tickets and schedules, call (212) 496-0900.

Planetarium Events

The Violent Universe. Starting January 4 at the Hayden Planetarium, this new Sky Show, narrated by Leonard Nimoy, delves into the mighty forces that shape the universe—black holes, exploding galaxies, even the birth of the cosmos itself. An array of special effects enhances this tour of our dynamic and ever changing universe.

Wonderful Sky. Through dialogue, song, and audience participation, children ages three through six explore the day and night sky, sunsets, rainbows, and distant twinkling stars. Tickets are $3.75 (adults) and $1.50 (children). For information call (212) 873-5714.

Laser Zeppelin and Laser Floyd. Laser visuals and the music of two famous rock groups combine to create a dazzling experience of sight and sound. See *Laser Zeppelin* on Fridays and Saturdays at 7:30 and 10:30 P.M., and *Laser Floyd* on Fridays and Saturdays at 9:00 P.M. Admission for participating, donor, and elected members is $4.00. Tickets can be purchased on the night of the show. For more information, call (212) 724-8700.

Pacific Peoples Celebration

To mark the opening of the *Margaret Mead Hall of Pacific Peoples*, the Museum's Education Department has planned a number of free weekend programs in the People Center. These include Mao dances from New Zealand; dances of Tahiti; traditional beliefs of Polynesia; a display featuring traditional foods and recipes of Polynesia; traditional music of the Philippines; and much more. All programs are free and open to the public and take place from 1:00 to 4:30 P.M. on weekends in January.

Pacific Peoples Film Program

A series of ethnographic films representing cultures of the Pacific islands will be shown on Saturday and Sunday, January 26 and 27, from 2:00 to 4:30 P.M. in the Kaufmann Theater. All films are free and open to the public.

Black Film and the Directive Image

A more positive view of blacks in our society is the theme of an anthology of films to be shown at 7:00 P.M. on three successive Wednesdays, in the Auditorium.

Wednesday, January 16. The Spook Who Sat By the Door. A story of the first black CIA agent, who uses his training to organize a black revolution.

Wednesday, January 23. Save the Children. This film of a concert organized by Rev. Jesse Jackson intercuts montages of black children with performances by such groups as the Temptations and the Jackson Five.

Wednesday, January 30. Ganja and Hess. A tale of a black anthropologist trying to unravel the mysteries of an ancient pre-Egyptian civilization.

ntain, and on June 18 he finally made the crater with a party of geologists various institutions. He later wrote, stood upon the rim of the great active er and looked upon a scene of wild and fying grandeur." Hovey took photohs of the scene and made extensive s for his scientific report.

n June 24, Hovey decided to attempt western side of the mountain, the most gerous route. Since the first eruption, mountain had been shrouded by storm ds and raked by lightning for much of time. On the way up, Hovey and his panions were soaked by torrential s. After making more observations at crater, they began to descend through rge. Suddenly, behind them, the main er began to erupt, enveloping them in and steam and obscuring what little they had. Closer at hand, but invisithe crew could hear a regular series of derous explosions. They had just sed the river flowing through the e when the ground began to tremble a ten-foot wall of black, boiling water ed past, sweeping over the place re they had been moments before. torrent rammed into a bank of ash sliced into its white hot interior, causan explosion of steam that shot hunls of feet into the air. Hovey and the rs barely escaped with their lives, and he wrote, "the whole formed a scene om witnessed, difficult to describe never to be forgotten."

he most terrifying sight of all, though, the city of Saint Pierre itself. Hovey r even attempted to describe what he "The devastation wrought by the tion," he wrote tersely in his scientific rt, "cannot be appreciated from a verdescription." It can be appreciated to e extent, however, from Hovey's phoaphs. They show acres of ruined build- blackened trees twisted into grue shapes, heavy accumulations of on the remains of cobbled streets. One ograph shows the ruins of a distillery re volcanic bombs had punched holes ick iron boilerplate. In another photoh, a cast-iron statue of the Virgin—hing several tons—had been ripped its pedestal and thrown fifty feet.

ovey gathered examples of the damnflicted by Pelée's eruption, and car- them back to the Museum in late Several of the volcanic bombs were layed, but the Museum administraquietly placed the other grim souvein storage. They were brought out for the *Volcano!* exhibition in 1979, will probably not be displayed again many years to come.

Douglas J. Preston

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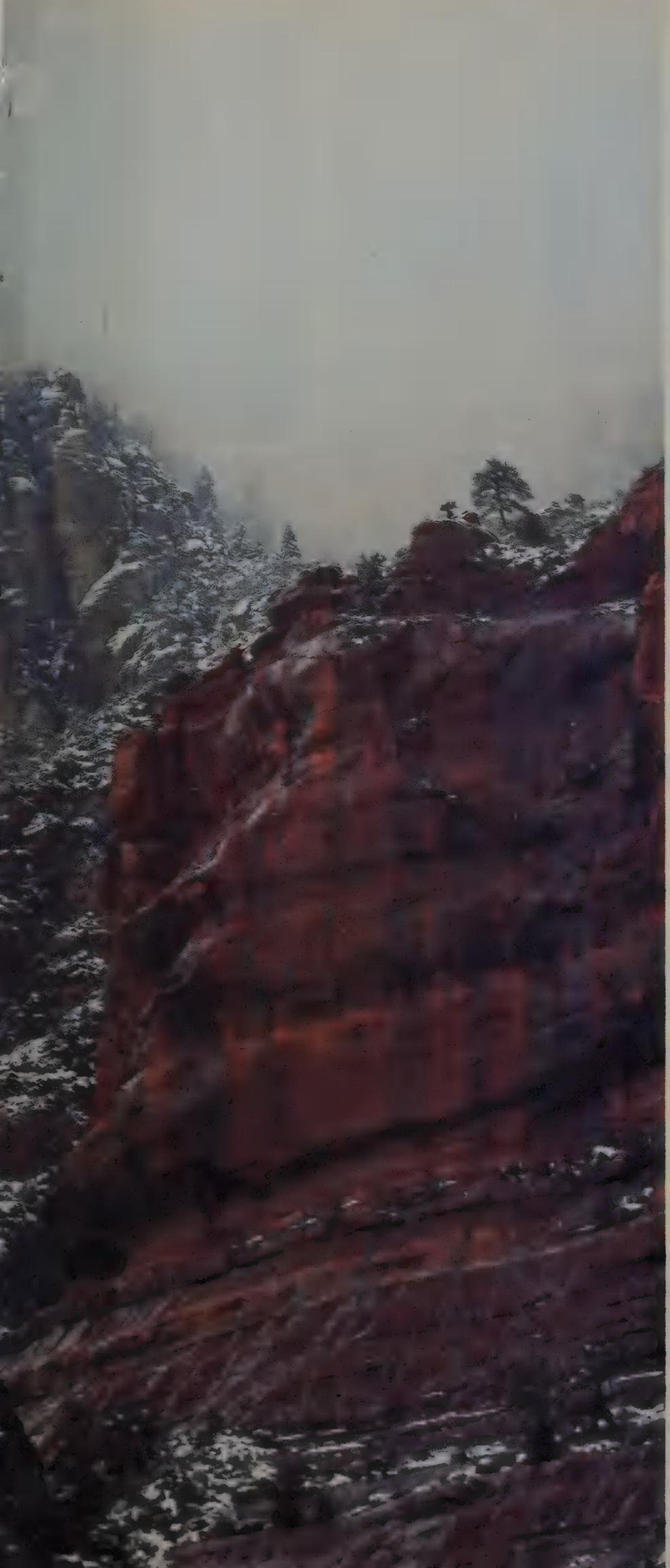


Oak Creek Canyon, Arizona

by Robert H. Mohlenbrock

One of the most abrupt geological features in the nation is Mogollon (mŭgēōn′) Rim, a 75-mile-long cliff that separates the cool, moist high country of northern Arizona from the hot, dry deserts to the south. Alternate Highway No. 89 plunges over the 1,000-foot rim and twists down steeply, finally bottoming out along Oak Creek. The highway then continues south, through a corridor of populated private lands surrounded by the wilderness of Coconino National Forest. In a few miles, close to the postcard-pretty town of Sedona, Oak Creek Canyon's red rock formations burst into view. Traffic slows as each turn in the road reveals cliffs, buttes, and occasional arches tinted in pink, purple, and fire-red. Finally, at Bell Rock, a few miles south of Sedona, the red rock country vanishes as suddenly as it appeared.

The canyon walls consist of five layers of rock, each formed by a different geological process. The bottom stratum, the Supai formation, is a series of brilliant red siltstones and shales, up to 1,800 feet thick, laid down by streams on an ancient flood plain. Above this is a 500-foot band of buff-colored Coconino sandstone formed by windblown sands, 200 feet of white Toroweap sandstone deposited by water, and a 300-foot layer of gray Kaibab limestone created from the shells and other remains of sea animals. Black lava from several volcanic flows caps the whole at certain places.

Sometime during the canyon's geological history, these rock strata slipped vertically, creating faults. Normally, when rock bends along a fault, the layers in the uplifted portion bend downward, and the layers that move down bend upward. In

Willis Peterson

Oak Creek Canyon and some of its side canyons, an unusual phenomenon can be seen: the layers of the uplifted rock bend upward and the downward-dropped strata bend down. Geologist Brainerd Mears suggests that Oak Creek Canyon's rocks did not bend when the faults were first formed. Sometime later, he argues, horizontal compression buckled the layers at the faults to create the pattern we now see.

This feature, called reverse drag, is particularly evident along one of Oak Creek Canyon's side canyons, West Fork, whose steep cliffs and gentle benches were cut by water draining from Mogollon Rim. (Zane Gray lived here for a while and was inspired to write his *Call of the Canyon.*) West Fork supports an exceptional diversity of plants and plant communities for such a small area. To preserve the region for study, the U.S. Forest Service has designated a portion of West Fork as a Research Natural Area.

The West Fork stream runs through one of the richest riparian habitats in Arizona. Dense colonies of jointed-stemmed horsetails grow in the shade of box elders, Arizona walnuts, New Mexican alders, bigtooth maples, and Gambel oaks. During the summer, patches of the showy, yellow monkey flower alternate with the horsetails. On my first hike along the West Fork, I encountered a small, much-branched tree whose fruits resembled hops. The tree proved to be Knowlton's hop hornbeam (*Ostrya knowltonii*), one of the rarest woody plants in the southwestern United States. This hornbeam, which was discovered in the Grand Canyon, also grows sparingly in southern Utah and again in the trans-Pecos area of Texas and New Mexico.

The box elder and Knowlton's hop hornbeam provide examples of how geographical distribution, ecological requirements, and external features—including the continuous or discontinuous gradation of characteristics—are important in determining whether a plant is a distinct species. The box elder, a member of the maple family, has one of the broadest geographical ranges of any woody plant in North America. Common in the eastern United States from Vermont to Florida, it is also found throughout the nation's heartland and as far west as central Montana, Nevada, and California. It even penetrates southern Canada and Mexico. Throughout all of its range, the tree displays similar compound leaves and pendulous, winged fruits. While box elders along West Fork have leaflets that are a little thicker and a little hairier than those of box elders back east, in all other aspects the plants are the same, including the stream bank habitat. In addition, box elders from all across the United States show only a gradual transition in thickness and hairiness of the leaflets. For this reason, botanists confidently classify the box elder as a single species.

On the other hand, botanists recognize two species of hop hornbeams in North America. The eastern hop hornbeam (*Ostrya virginiana*) lives from Nova Scotia to Florida, and west to the Dakotas, eastern Texas, and into Mexico. This small tree usually inhabits moist but well-drained slopes and ridges. It has pointed leaves and two-inch-long fruits. Several hundred miles to the west, a second hop hornbeam with rounded leaves and fruits that barely reach one and one-half inches in length grows in isolated rocky canyons. This is Knowlton's hop hornbeam, considered a distinct species because of its geographical isolation from the eastern hop hornbeam and because of the marked variation in its leaves and fruits.

The remarkable biological feature of West Fork is that within just a few hundred feet of the wet, riparian habitat, there are two other, very different environments. Where the canyon runs almost due east–west, the slopes that face southward enjoy relatively dry conditions, and the branched, leather-leaved shrubs have developed into a brushy, dry plant community called chaparral. Many areas of the chaparral are almost impenetrable because of the entangled growth of the pointed-leaved manzanita, mountain ma hogany, silk-tassel bush, and shrubby liv oak. Prickly pear cacti and century plant found in openings in the chaparral, are re minders that the desert is not far away.

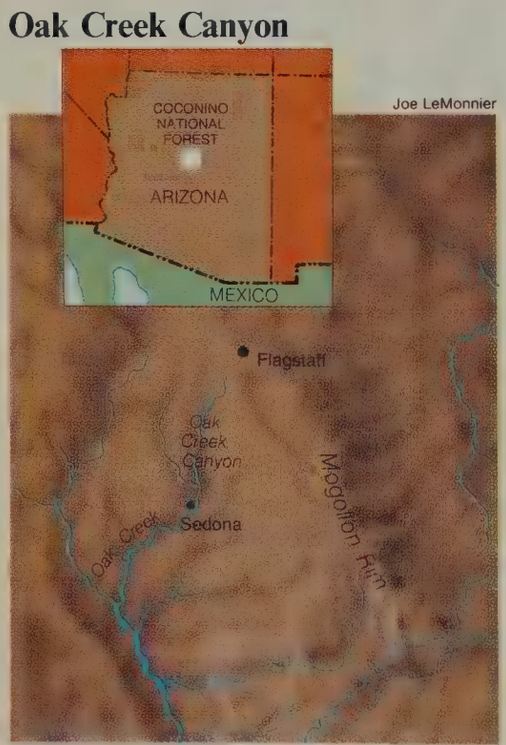
A short distance from such warm, dr areas are stands of Douglas fir and por derosa pine, trees normally expected a higher elevations, such as Mogollon Rir itself. These are able to grow where th canyon bottom is densely shaded. Suc cool and moist conditions are especiall evident in West Fork's narrow side can yons, where the steep walls block the sun' rays. The upper ends of these side canyon are natural channels for cool air.

Beneath these conifers is a contrastin mixture of the pink-flowered New Mexic locust and the Gambel oak. The quiet ob server may hear or see an Abert's squirre a golden-mantled ground squirrel, a wes ern tanager, or a pygmy nuthatch as scurries down a tree trunk.

Although Oak Creek and West For canyons can be visited at any season of th year, the traveler must be prepared fo temperature fluctuations. Summer tem peratures average 75 degrees Fahrenhei but occasionally climb to 100. In winte the average temperature is between 3 and 40 degrees, but it can fall below zer on the rim. Afternoon thundershowers ca be expected during July and August, an there may be snow or light, steady rai during the winter.

"This Land" highlights the biologica phenomena that can be explored in th 153 United States national forests. Rob ert H. Mohlenbrock, a professor of bo any at Southern Illinois University a Carbondale, is author of The Field Guid to U.S. National Forests.

Oak Creek Canyon



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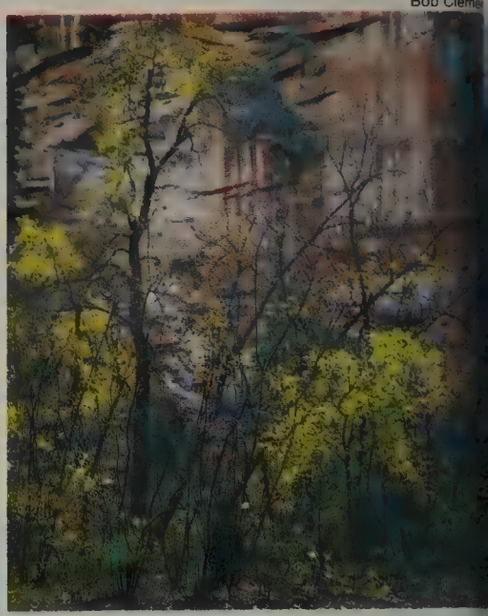
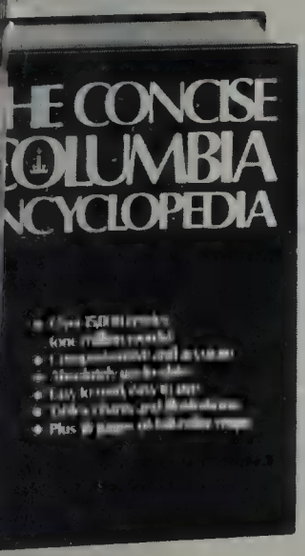

Bob Clemer

Golden cottonwoods occupy part of Oak Creek Canyon's West Fork.



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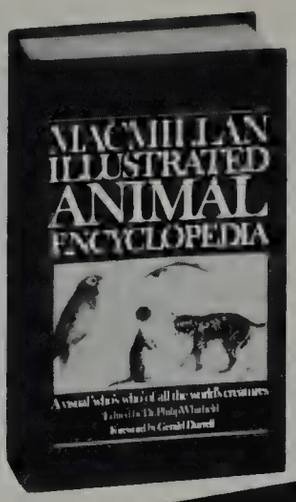

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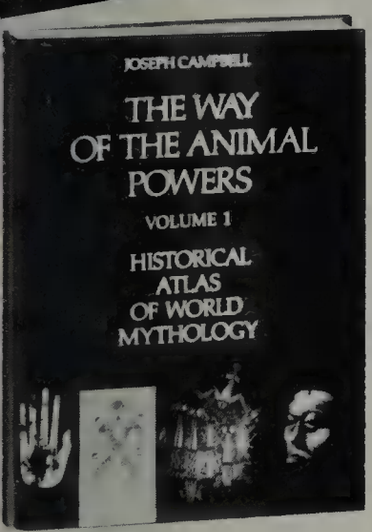

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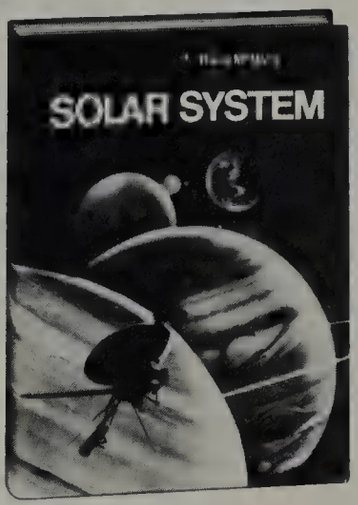

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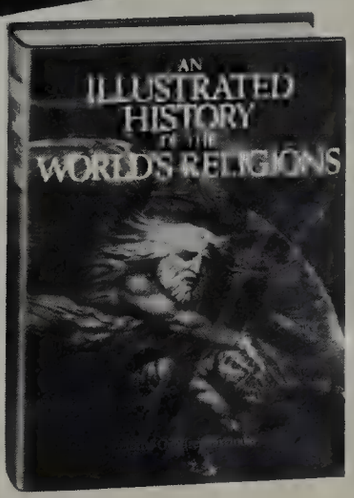

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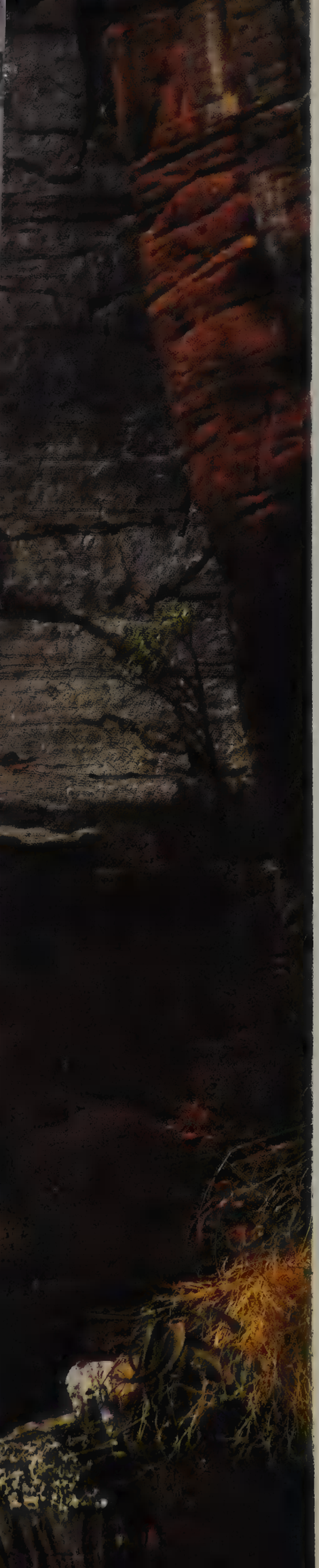


Bald ibises nest exclusively on cliffs and are found only in the highlands of southern Africa.
Peter Johnson

Birds of Fire

Is the bald ibis's affinity for burned grasslands an acquired taste? Or is it an ancient product of evolution?

by David E. Manry

The Drakensberg escarpment of southern Africa rises abruptly out of the gently rolling landscape of the Natal midlands. From a distance, it resembles a colossal fortress wall, towering more than 3,000 feet above the fractured sandstone terraces skirting its base and surmounted by a lofty, summit plateau almost two miles above sea level. From the Soutpansberg Mountains in the Transvaal (the northernmost province of South Africa) to Xalanga Peak in the eastern Cape Province, the escarpment winds almost continuously for more than 1,000 miles, creating the twisted mountainous backbone of the southern African subcontinent. From June through August (winter in the Southern Hemisphere), its basaltic crags and precipices are often completely blanketed in snow; on sultry summer afternoons (December through February) dark thunderclouds loom ominously above its jagged crestline before sweeping over the adjacent foothills.

Extending from the escarpment on both sides is a vast expanse of open grass country, referred to by ecologists as the South African grassland biome. Rising gradually from about 900 feet to more than 11,000 feet above sea level, and covering an area of approximately 126,000 square miles, the grassland is a self-contained habitat "island," surrounded at lower elevations by heath, woodland, and semidesert plant communities. Many plant and animal species are unique to this sprawling grassland, which may have originated as recently as sometime during the Pleistocene period. One of the rarest and most peculiar of these is the bald ibis (*Geronticus calvus*), found nowhere else in the world but the wind-swept grasslands flanking the Drakensberg escarpment. I traveled to the province of Natal, South Africa, in May of 1978 to begin a three-year field investigation of this unique bird. In the process I discovered how important events in its annual breeding cycle are timed to exploit the pattern of insect abundance and availability created by grass fires.

The bald ibis is one of thirty-two different species in the avian family Threskiornithidae, found on all continents except Antarctica. Often highly gregarious, ibises forage in flocks during the day and retire to communal roosts in the evening. They are commonly associated with marshes and other aquatic environments where, by probing in soft mud with their long, curlewlike bills or groping in shallow water, they prey on a wide variety of small animals, including worms, mollusks, crustaceans, insects, fishes, and amphibians.

In keeping with their sociable habits, most ibises breed in colonies numbering from a few pairs up to several thousand, although for some species, solitary nesting is the rule (a few species nest both colonially and solitarily). Most ibises place their nests—sturdy, bowl-shaped platforms composed of loosely interwoven sticks and twigs and lined with a thin layer of grass or some other fine material—on a branch in a tall tree or bush, in dense reeds, or even on the ground when nesting on remote islands safe from predators. The bald ibis, however, breeds exclusively on sheer cliffs. Mated pairs construct their nests well out of the reach of most predators—on narrow, exposed ledges, in potholes high up on mountainsides, in river gorges, and at waterfalls. The only other ibis species that breeds exclusively on cliffs is the bald ibis's sole congener, the waldrapp (*G. eremita*) of Morocco and Turkey, an endangered species very simi-

Nearly fifty bald ibis pairs nest on the cliffs beside the Mooi River, below, in Natal Province, South Africa. The local landowners' practice of burning back ungrazed pastureland, left, provides the birds with a windfall diet of roasted insects during winter and spring.

Mandy Hedden

David Manry

lar in habits and appearance to its southern African counterpart.

The bald ibis is confined to rugged, mountainous country in the eastern Republic of South Africa, extending marginally into the adjacent kingdoms of Lesotho and Swaziland. In South Africa the species was formerly found in the Cape Province as far west as the Atlantic coast, but by the turn of the century the bird had vanished from the western portion of its range, perhaps as a result of overhunting and other human disturbances. Today it no longer breeds in the Cape Province. Moreover, recent decades have seen its numbers diminish in some areas where it has managed to survive. The contraction of the bald ibis's range and its diminution in numbers are particularly ominous because the waldrapp, its closest living relative, has suffered an even more drastic attrition in recent years and today ranks among the rarest of birds.

Some conservationists believe that the bald ibis is also in serious jeopardy. Up-to-date information is lacking, but in 1971 its total breeding population was estimated at only 2,000 birds. The species' vulnerability underscores the need for basic information about its feeding ecology, habitat requirements, and reproductive potential.

My study area was located at approximately 4,000 feet above sea level in what was predominantly open grass country, punctuated by scattered, cultivated fields and crisscrossed by plantations of exotic trees. Winters are cold and dry, with temperatures dropping well below freezing almost every night, while the spring and summer months (September–February) are generally warm and rainy. For three consecutive breeding seasons (1978 1980), I lived in a rustic, mud-and-thatc hut near a spectacular, 130-foot-high w terfall on the Mooi River, where approx mately forty-eight pairs of bald ibis nested each year. Throughout my invest gation I kept track of the number of ibis in the colony at different times of the yea and during each breeding season (prima ily June–November) I monitored the r

luctive activities and success rate of
esting pairs.
ne of the primary goals of my re-
ch was to elucidate the bald ibis's
ing ecology by examining its choices
oraging habitat in different seasons.
sampling technique was straightfor-
d and nondisruptive: each time I en-
ntered the birds feeding, I recorded
number of individuals present, the

A yearling bird (foreground) forages with an adult on recently burned grassland. Winter burning of firebreaks is particularly well timed to provide abundant, easily procured protein during the coldest time of the year.

David Manry

type of vegetation they were foraging in, and sundry details such as foliage height, weather conditions, date, and the time of day. As my observations accumulated, I was surprised to discover that the bald ibis, unlike most members of its family, is strictly a terrestrial forager. It feeds exclusively in natural grassland and cultivated fields, where it consumes beetles, grasshoppers, and other small animals. The birds are rather fussy in selecting the areas they forage in, preferring level terrain where the foliage has been either cropped short by grazing ungulates or burned off. Here they move rapidly with little interference from the sparse vegetation, which provides scant cover for fleeing prey. As an additional bonus, recently burned grassland is littered with dead insects fallen victim to the fire, providing a feast for bald ibises and other insectivores. These fire-killed insects are only slightly scorched and no less edible than their living counterparts. Once located, they require no additional pursuit, so the birds spend less time and energy chasing after meals.

Burning occurs annually in the bald ibis's grassland habitat, and the bird's relationship with fire is remarkably complex. Modern landowners burn the grassland in two distinct seasonal phases. During autumn (March–May), as rainfall and ambient temperatures steadily decline, the grasses prepare for their long winter dormancy, withdrawing most of the nutrients in their leaves to their root systems and releasing surplus moisture to the air. As the foliage withers and dries out, the entire grassland becomes highly inflammable, increasing the threat of destructive, runaway fires.

Therefore, as a safety precaution, landowners burn wide strips of grassland across their properties from late May till the end of July, creating a protective network of firebreaks throughout the landscape. This is the first burning phase. During winter bald ibises forage extensively on these firebreaks, feasting on the numerous dead insects present immediately after burning and returning periodically in succeeding weeks to search for live prey that persist in the grassland long after the fires are extinguished. Since firebreaks are burned annually, the birds are assured of a plentiful and predictable supply of easily procured food during the coldest and driest time of year.

With the arrival of the first spring rains, usually in late August, landowners again burn the grassland, this time in vast sections. This second, far more extensive controlled burning eliminates moribund fo-

Pair bonding often extends beyond the breeding period, so that copulation, below, does not always signal readiness for egg laying. Males of adjacent nesting pairs, top right, engage in the bloodless combat of ritualized bill sparring. An incubating adult, far right, turns its eggs, while another sits tight. Both sexes incubate the eggs; the changing of the guard is accompanied by an "ecstatic" greeting gesture, bottom right.

All photographs by David Manry

liage left over from previous growing seasons and promotes fresh growth for livestock. As the season advances, grasses emerge from their winter quiescence and resume active growth, sending up new shoots to the surface and providing optimal forage for grazing ungulates and herbivorous insects alike. In South Africa, national and provincial laws limit the duration of the controlled-burning season from mid-August to the end of October. Throughout this period bald ibises forage extensively in these vast burned areas, preying on the numerous insects attracted to the nutritious, postfire regrowth. However, the extent of grass burning in any given year depends greatly on the amount of rain that falls before and during the prescribed period. In wet years up to 40 percent or more of the total grassland area may be burned, while during a severe drought almost no grass is burned apart from firebreaks. The birds must then seek other foraging habitats, resorting mostly to cultivated pastures and unburned grass that has been heavily grazed.

The bald ibis's annual cycle, and particularly the timing of its breeding activities, tie in closely with the controlled burning rhythm in its grassland domain. Birds that temporarily vacate their colonies during the nonbreeding period return from their wanderings in early winter, soon after the resumption of firebreak burning, to join up with their previous mates or to form new pair bonds and reestablish their ledgetop breeding territories. Whereas from January to early May the birds spend most of the day foraging afield, retiring to the colony in late evening to roost overnight, beginning in late May they return to the colony much earlier in the day, sometimes after only three or four hours of active foraging early in the morning. Such a drastic reduction of the daily foraging period attests to the abundance of food to be found on burned firebreaks during winter. For the remainder of the day, the birds may be found at the breeding colony, guarding their nest sites against intruders and engaging in courtship activities, mating, nest building, preening, loafing, and bathing in the river. Ironically, winter is a time of relative leisure for the bald ibis, when most other grassland inhabitants are struggling for survival. In late July or early August, the females begin to lay clutches of two or three eggs.

In late August, as fresh growth reemerges on the firebreaks, the first ibis hatchlings emerge from their eggshells. Completely helpless at birth, the nestlings spend their first seven weeks or so confined to their natal ledges, where they a cared for by both parents. They are fed gurgitated insects gathered primar from freshly burned grassland, fro older, greening burns, and from cultivat ryegrass pastures, which serve as a back food source when burned grassland is short supply. During the last stages of development, the nestling frequently p forms flight exercises *in situ*, flapping wings energetically while jumping up a down on its ledge, preparing for the d when it makes its first flight. In a fav able year with abundant rains, when sects are abundant and burning wi spread, 45 percent of all breeding tempts produce one or two fledged o spring. During a severe drought, howev little grass is burned and the birds suff on two accounts. Prey is not only mo scarce but also more difficult to catch

unburned grass. In such years most eeding attempts end in failure, and ne pairs refrain from nesting alto- her.

After fledging, the young ibis begins to plore the cliffs around its nest site, min- ng with other fledglings in the colony ile waiting for its parents to return peri- ically with food. The fledging period ex- ds from mid-October to late Decem- , although most chicks are fledged by d-November. Two or three weeks after dging, the young initiate accompanies parents to the feeding grounds for the t time and begins to develop the forag- skills necessary to become self-suffi- nt. The adults continue to provide sup- mental feedings to their offspring for other two months.

By early summer, when most burned ar- s are covered in tall, postfire regrowth, bald ibises shift to feeding in heavily grazed grassland and cultivated pastures, where the foliage is kept comparatively short. Plant growth is rapid and nutritious herbage abounds, and insects are now approaching their annual peak in numbers. However, the height and density of the vegetation force the ibises to search more carefully for their inconspicuous quarry, slowing their progress and reducing the number of successful captures made in each hour of hunting.

Interestingly, most pairs complete their nesting cycle before summer, raising their ledge-bound progeny during spring, when insects are generally less abundant but are more readily available in burned areas. Later on, when the new fledglings are able to commute to the feeding grounds with their parents, the adults can better afford the extra time needed to locate prey in suboptimal habitats; the time previously spent traveling between hunting ground and nest can now be used for capturing insects with the fledglings at their sides. Moreover, early nesting allows the young birds to develop their own hunting skills in the summer, when insects are most numerous. Thus the number of free-flying birds in the colony and the number of insects in the grassland reach a peak together in late December.

The bald ibis is not distributed throughout the grassland biome but is concentrated in the high-rainfall zone along the Drakensberg escarpment and its main outliers, between 3,000 and 7,000 feet above sea level. The first Europeans who began settling this region in the early 1800s designated the highland grasses as "sour," referring not to their flavor but to their low nutritional value to livestock during the winter months. Because sour grasses withdraw most of the nutrients in their foliage to their root systems during autumn, they are relatively unpalatable to grazing ungulates until the renewal of growth in early spring. Before the advent of artificial feed supplements, livestock had to be herded to lower altitudes each autumn, to rangelands dominated by sweet grasses, which remain nutritious year-round. There they could graze throughout the winter, before being rotated to the highlands again in early spring.

Although grassland ecologists have yet to determine why some grasses are sour and others sweet, they do know that sour grasses tend to grow at high elevations, where annual rainfall is high and soils heavily leached and highly acidic. Sweet ones, on the other hand, predominate at lower altitudes, where the climate is drier

A male parent stands guard over two nestlings, below. A full-time guard is necessary to insure survival of young chicks, which are often harassed by unrelated adults. Opposite: River bathing may be particularly important when ash accumulates in a bird's feathers.

David Manry

and the soils less acidic. Intriguingly, the breeding range of the bald ibis follows the distribution of sour grasslands along the major watersheds and does not extend into the sweet grasslands covering the lower basin regions. Could it be that the birds also recognize the distinction between sweet and sour grassland, and if so, why are they so partial to the latter?

Regional differences in burning frequency could be of crucial importance to a pyrophilous species like the bald ibis. Nurtured by abundant annual rains, sour grasses produce tremendous amounts of herbage during each growing season. Ungrazed foliage must be burned off once every two or three years or the grasses begin to die under the burden of their own accumulating litter and are replaced by weeds, shrubs, and tree seedlings. On the other hand, this problem is rarely encountered in the drier sweet grasslands, where livestock more thoroughly graze the less prolific growth. Here excess foliage rarely has a chance to accumulate.

Landowners may burn their sweet pasturage once every ten or fifteen years to eliminate undesirable plants that invade during a prolonged absence of fire or after an exceptionally wet rainy season, when the sudden flush of growth greatly exceeds the grazing capacity of resident livestock. Otherwise, burning is generally discouraged in the sweet grassland and is rarely practiced. That the bald ibis is restricted to the type of grassland subject to the highest frequency of burning under modern farming systems and is absent from those areas where grass fires almost never occur suggest that burning frequency may be an important factor determining the present limits of its restricted range.

Modern grass-burning procedures have developed gradually over the past century, and the bald ibis has accommodated itself to these artificial fire regimes imposed by recent European settlers on its grassland domain to such an extent that it may now depend on frequent grass fires for its viability as a species. But fire is not new to this region, and the bird's relationship with fire is probably an ancient one. Undoubtedly, the Iron Age pastoral communities that migrated to southern Africa from the north approximately 1,800 years ago tended sheep, goats, and cattle and burned grass regularly in a manner similar to the modern practice. Prior to their arrival, the grassland was populated for millennia by nomadic Stone Age communities that subsisted entirely by hunting and gathering. These early inhabitants burned off large areas of grassland both to stimulate flowering in important food plant that conceal their edible portions under ground and to attract game close to their encampments. Stone Age cave painting in the Drakensberg depict the bald ibis i its characteristic foraging posture, sug gesting that it occupied a special place i the folklore of these communities.

No one knows when people first bega burning the vegetation of southern Africa although recent archeological findings i Zambia indicate that central African cu tures were proficient in the use of fire a least as early as 750,000 years ago. Hov ever, a growing body of evidence suggest that fire was a regular event throughou the grassland biome long before people be gan using it there. Today, the single mos important natural cause of fires in vegeta tion is lightning, and the grassland biom experiences the highest frequency of ligh ning in all of southern Africa, averagin more than thirteen ground strikes pe square mile annually. Along the Draken berg escarpment, the abrupt topographi changes provide ideal conditions for th formation of thunderstorms, and the ligh ning frequency increases to forty groun strikes per square mile annually.

Obviously, the potential for lightning ignited fires is extremely high throughou the grassland biome, particularly alon the Drakensberg escarpment. Conse quently, the local flora has evolved t withstand frequent burning. Indeed, witl out occasional fires, the grassland is grad ually invaded by weeds, shrubs, and othe precursors of successionally more ad vanced plant communities and is eventu ally converted into forest, heath, or wood land vegetation. Thus, the grasslan biome may owe its origin to the high fr quency of lightning storms generate along the Drakensberg escarpment, whic ignited fires at sufficiently short interva to prevent shrubs and tree seedlings fro becoming firmly established, and whic promoted the fire-resistant grasses an forbs in their stead. If this scenario is co rect, the bald ibis's predilection for feed ing in burned areas may be the result of long, ongoing process of natural selectio rather than a fairly recent accommoda tion to human burning practices.

The Little Foxes

They may look endearing, but young red foxes fight violently and, when necessary, steal food from one another

by J. David Henry

It happens during the coldest part of the year—a time when northerners bundle up against twilight days and −40 degree air with parka and wind pants, gauntlet and mukluk. It is a time when darkness pervades the forest, when everything seems brittle.

Yet, during this inhospitable period in late January or early February, while most animals are simply trying to survive the frozen wastes of a boreal winter, red foxes begin to court. It is not difficult to know when the foxes are feeling amorous; a musky odor begins to emanate from the urine they leave in the snow. This scent is particularly strong in the urine of males. In Prince Albert National Park in northern Saskatchewan, where I do my research, foxes develop this breeding odor over the course of a week or so. Then, for the next month or six weeks, a skunky fragrance permeates the woods wherever a red fox and his vixen have established their territory, the area they use for hunting and scavenging and defend against other foxes. After studying foxes for years, I can say with confidence that it is my nose, more than anything, that first tells me the foxes are courting.

During this amatory interlude, the dog fox and vixen, both of which have been leading solitary lives on the territory, now begin to seek one another out. They travel together for several weeks, becoming increasingly confident about touching one another, until they finally breed. During the courtship period, the vixen visits and cleans out several lairs on the territory, one of which she will choose as her whelping den.

Why does a vixen choose to give birth to her pups in one place rather than another? What does she see in a particular piece of earth? After surveying thirty-five whelping dens, I found that they have certain typical characteristics. The den is usually located on a hillside in sandy loam. It is often in the forest but close to a meadow or open slope. And it usually has multiple entrances, the largest one about ten inches in

This article was adapted from *Red Fox: The Cat-Like Canine*, by J. David Henry, which will be published this year by Smithsonian Institution Press.

A red fox plunges through a January blizzard in Ontario. At Prince Albert National Park in northern Saskatchewan, red foxes begin to seek out mates in the worst cold of winter, and their urine takes on a musky breeding odor.

Wayne Lankinen; Bruce Coleman Inc.

diameter. Finally, the den retreat is normally within one hundred yards of a water source, although this source can be anything from a large lake to a humble pool in a muskeg. With these requirements, vixens have to be selective about where they bear and raise their cubs.

Certain features, such as the nearby drinking water, have obvious advantages; but I was not sure I understood the others. Why are they so common? After reflecting about them, I feel that vixens probably select sandy loam because they can dig into it more easily, but it could also be that this soil, combined with the hillside location and nearby open area, may make for a site where snow melts early, frost leaves the ground quickly, and drainage is always good. Vixens use the surrounding forest for shelter and escape; they can sun themselves in the adjacent meadow and their rambunctious pups can play there.

A vixen may use the same whelping den year after year, and when she dies, the site may be passed on to one of her daughters. One fox lair near my cabin, for instance, has been active for nine of the last twelve years. Since adult foxes in the wild usually live only three to seven years, this den was probably occupied by several different fox families. On the other hand, abandoned lairs that deteriorate may be renovated by foxes after a long vacancy. The first den I ever studied in detail, in 1972, was active until 1974. After that, it lay vacant until a young fox couple reoccupied it and raised a family there during the spring of 1980.

Foxes never seem to rely on just the whelping den, however. In my area, they always have other, smaller burrows hidden away on their territory. If disturbed or threatened at the whelping site, the vixen or dog fox will simply move the pups to a new location. Frequently, the vixen initiates the move, which sometimes leaves her mate in a quandary.

I remember one such experience when, for an extended period, I was observing foxes at a den twenty-four hours a day in order to document how the six-week-old pups were being raised. One afternoon, in an attempt to get some photographs, I unwittingly crossed an invisible but important vulpine boundary, and the vixen reacted as if she had decided enough was enough. She waited until the middle of the night and then moved the pups, not carrying them as other canids do but marching them along behind her. About first light the dog fox returned to the den with a rabbit in his mouth. He went to the main entrance and called the pups with the rapid "wuk . . . wuk . . . wuk" chortle that foxes use, but no one came forth. Setting the rabbit down, he began to smell around the area. He apparently was able to figure out what had happened by the odors that remained on the ground. Sniffing the site thoroughly, he finally detected the trail that the vixen and four kits had taken through the forest. He returned to the den, hid the rabbit, and then began to track down his family, following their scent through the bush. On the other hand, I, not being blessed with the nose of a f spent the next seven days searching in v for the new den site.

But I am getting ahead of myself. I me backtrack and follow the pups throu their eventful early life. After a gestat period of fifty-two days, the kits are bo in my study area this occurs during l March or early April. The average lit comprises five whining, hungry mout but a litter of nine cubs is not uncomm Regardless of the size of the litter at bir some cubs usually die. The number t survive depends, among other thin upon the amount of food the adult fo can find on their territory.

When the kits are born, they are he less and weigh less than a quarter o pound. Except for their smaller size, th are remarkably similar to newborn coy

chmidt

uple of red fox kits, left, with their juvenile fur—a sandy-red coat—nurse outside their den. Young foxes suckle until are about five weeks old, at which point they start spending er periods outside the den and are weaned. Below: A pair der siblings play at fighting.

ıline; Animals Animals

d wolf pups—with one important ex-ɔtion. Even at birth, most young foxes ve a curious white tip on the tail. Red es retain this white tag throughout ir lives, and they are the only North ıerican canid species to show this dis-ctive marking.

During their first month of life, young es do not possess the brilliant red coat t is the hallmark of the species; instead, ir coats are charcoal gray. Foxes are the only canids with this feature. At th, the whelps of coyotes, wolves, and er species of wild canids are also aked with dark gray fur. As far as I can ermine, this special natal fur does not ve any physiological function. It may ve as camouflage while the young ıids remain in the darkness of the den. Fox kits grow slowly during their first v weeks; their eyes do not open until y are ten or twelve days old. During ly life, the vixen constantly attends m. In many areas, the vixen may ven-e out of the den after only two days, but ıorthern Saskatchewan she remains in-e constantly from a few days prior to th until the kits are approximately ten ys old. She is completely dependent on male for her food during this period. is he provides with regularity.

Why is the vixen unwilling to leave the kits? David Macdonald, who has studied red foxes extensively in Britain, suggests that the kits are so small and vulnerable during early life that the vixen must surround them with her warm body if they are to survive. This maternal protection becomes increasingly important the farther north one goes. At the time the kits are born, the ground in northern Saskatchewan is still frozen and covered with snow. The den is damp, and the air temperature inside is a chilly 32 degrees Fahrenheit or colder. The vixen acts literally as a thermal blanket, protecting the cubs in their frosty underground chamber. One could almost say she incubates them.

The vixen begins to leave the den and resume her normal travels when her cubs are about two weeks old. By then they are well furred and large enough to maintain their own body temperature. She now spends more and more time away from the lair hunting for prey for herself, but she continues to receive some food from her mate. And she does return to the den at regular intervals to nurse the kits. While in the den, she attends to her other maternal duties as well. She plays or naps with the cubs and then grooms them—cleaning out their ears, licking their groin regions, and eating their waste products. She maintains this routine until they are five weeks old, when she begins to wean them.

The early life of a kit fox is not the carefree, leisurely existence that one might imagine. It is business from an early age. During their second week, the kits begin to grow faster and their milk teeth start to come in—canines first, followed by incisors, and finally, premolars. During their third week, they begin to experiment with their teeth. They chew and suck on meat that the parents have brought them and learn to enjoy the juices found in a freshly killed rabbit. Now they enter an important phase of their development.

At this time, the fox kits are far from fully coordinated and have been aboveground only for short periods. Yet at about twenty-five days of age, they begin to fight viciously; they clash with each other in short, serious, and sometimes fatal contests. (Fatalities are rare, however.) Fox kits do not act like cute, cuddly puppies such as those of the domestic dog; rather, they have always seemed to me to have a slightly demonic character about them. They are tough, month-old thugs, little street fighters that initiate fights and, over a period of ten days, establish a strict dominance hierarchy. The alpha (or dominant) member of the litter establishes itself, and the process continues all the way down to the weakest animal.

Evidence suggests that these dominance relationships among the cubs remain stable and have a great bearing on their survival. If the adults are bringing the kits only a limited supply of food, competition for it is keen. By establishing a hierarchy, the kits determine who can steal food from whom. The largest member of the litter, whether male or female, usually becomes the alpha pup. Using either intimidation or direct attack, this animal steals food from its littermates. Each pup steals food from littermates below it in the hierarchy. It is a blunt fact of a fox's life that the dominant pups get a larger portion of the food and have the best chance of surviving, while smaller and submissive ones may perish. The runt of the litter usually dies first, then the second lowest in the hierarchy, and so on. It is a brutal process; but given the constraints of the hierarchy, it is the only way healthier kits can sur-

A red fox mother stalks a ground squirrel that ventured too far from its hole. The squirrel bolted, the fox leaped, and about ten yards later, the vixen had a meal for her kits. In fox families, both parents usually hunt in order to feed the young.

Brian Milne; First Light

vive. Nor have parent foxes evolved to interfere with this sibling rivalry, since the competition results in a litter composed of the healthiest whelps. Pared down, the litter size is also now in balance with the food resources of the territory.

By early May the fox kits in my area begin to come aboveground for longer periods of time. At this point, the hierarchy is solidly established and, with that crucial matter out of the way, the aggressiveness of the cubs actually diminishes. Gradually, they become more social, playful, and puppylike. It is at this time that most people first see young foxes. How much has happened in their lives before we are even aware of them!

When a parent fox returns to the den during early May and chortles for the pups, they stumble out—unsteady on their feet, blue eyed, and still dark coated. But at about this time an important change takes place: at about five weeks of age, they start to lose their dark natal coat and get a new pelage. Once again it is not the brilliant red of an adult fox, but a sandy-colored juvenile coat that almost perfectly matches the sandy soil of the den site. This coat helps to camouflage the pups around the den and protect them from occasional predators, such as hawks, owls, and coyotes.

Reflecting on the sandy-colored coat, I began to realize that this juvenile pelage had come about from an interesting series of events. I can imagine it evolving something like this: At first the vixen tended to dig her whelping den in sandy loam simply because it afforded good digging. But over time, the fur of the kits slowly evolved to match the soil's color. Evolutionary theory states that, if the sandy-colored pups have even a slightly better chance of surviving, all fox kits will eventually develop this coloration. As this happened, there was greater pressure on the vixen to locate her den in sandy-colored soil. Consequently, the selection of the den by the vixen and the juvenile pelage of the kits are coadapted to protect the young during their vulnerable first month outside the den.

This buff coat of the young foxes is actually a specially colored underfur (the underwool of adult foxes is a dark gray). The kits keep this juvenile coat for approximately five weeks, but starting in early June, outer red guard hairs begin to grow through. By the end of June, kits display the bright red coats normally associated with adult foxes.

When the kits are five weeks old, they begin the transition that will launch them into adult life. The pups now begin eating solid food, and the vixen starts to wean them. Weaning fox pups is an uncom
cated procedure. If the kits try to nu
the vixen rolls over on her stomach. If t
persist, she threatens them and runs o
short distance. She becomes increasin
unreceptive to their suckling, and by
time they are eight weeks old, the pups
completely weaned. But being wea

Overleaf: *A young dog fox ranges the Alaskan tundra in Lake Clark National Park.*
Jim Brandenburg; Woodfin Camp and Associates

A vixen hurries homeward with the results of her latest expedition. Very young foxes suck and chew at meat but don't swallow it. Only during weaning do they start eating solid food.
Stephen J. Krasemann; DRK Photo

oesn't mean being cut off. The parents ontinue to hunt and scavenge at different mes of the day and night in order to upply the kits with sustenance. These dults bring in an assortment of prey nd present it to their pups. For example, n one week the menu included rabbits, nice, voles, squirrels, groundhogs, songbirds, grouse, and a spawning long-nosed sucker.

Distributing this food is a household ritual in a fox family and always happens in the same way. Carrying the item in its mouth, the adult fox arrives at the den, chortles, and one or more of the pups rush out to greet it. The first pup to reach the parent crouches low and beats its tail about wildly. The kit whines and creeps toward the adult and then reaching up, it smells, licks, and bites at the corners of the adult's mouth.

There seems to be a consistent rule in fox families that the adult will give the food to the first pup that begs for it. This

W. Ruth; Bruce Coleman Inc.

Below: An older kit (left) takes food from its parent (right) while another (center) waits for a chance to break in. Foxes clash violently with each other when still very young, setting up a dominance hierarchy. This determines which pup can steal from which and, if food is scarce, may decide which ones survive. When kits reach the age of nine or ten weeks, parents start supplying less food, as part of a campaign to make the youngsters more independent. Right: A parent checks the den.

Stephen J. Krasemann; DRK Photo

way, supplies are more or less evenly distributed. Basically, the hungriest pup keeps the best watch, gets to the parent first, and is given the food. However, once it has received its ration, the kit still has to defend its prize against littermates, either by running off or by threatening any siblings that come near. As I explained earlier, a dominant pup will frequently challenge and steal the provision from its subordinate littermate.

Food-begging behavior, by the way, also appears many months later but in a completely different context—as part of the submissive behaviors shown by adult foxes. When two full-grown animals meet, the subordinate fox often acts as if it were a young pup, begging to be fed. It crouches low, whines, and beats its tail madly in every direction. This keeps the white tip of the tail in constant motion (much like waving a white handkerchief) and lets it function as an attention-getting device. The subordinate fox slowly creeps up to the dominant fox and carefully reaches up to smell and lick the corner of its mouth. This use of infantile behavior by adults is not unique among red foxes. Embracing among adults, which is used as a greeting and reassuring gesture not only among humans but also chimpanzees and baboons, may be derived from infantile grasping. People in love sometimes coo and baby-talk to each other; we sometimes stammer or show shy juvenile behaviors when introduced to famous people.

The role of the dog fox in raising the kits has been debated among naturalists and field biologists. Some state that the male fox is never seen around the den, while others conclude that he supplies most of the food for the pups. There must be considerable variation among red foxes of different areas. The causes of these differences are not fully understood. But in Prince Albert National Park, an area where the foxes are almost completely protected from hunting and trapping, I have consistently observed male foxes bringing food to the pups until they are approximately ten weeks old.

In addition to the parents, other foxes will occasionally feed the pups. These "helper" foxes are an interesting phenomenon. Most often the assistant appears to be a daughter from the previous year's litter that has stayed on the family territory but not given birth to pups of her own. When she is present, she makes a definite contribution to rearing.

This helper illustrates an important point about evolution. Evolutionary theory states that individuals of a species that are most physically and behaviorally fit will leave the greatest number of o spring. But twenty years ago, British bio gist W.D. Hamilton stressed that an in vidual's relatives are also important. F example, red fox helpers are as closely lated to their full siblings as they would to their own offspring. If an assistant creases the survival rate of her young brothers and sisters, she helps some of h own genes survive into future generatio

Foxes that aid in raising their young brothers and sisters may also derive oth benefits. For example, they may gain e perience that will help them rear their o offspring more successfully. In a fe cases, they may also inherit part of th parents' territory.

Hamilton's theory makes another p diction about these young vixens. It sta that if food is scarce, the daughter w help raise and feed her mother's litt

wever, if food is abundant, the male fox breed with both the older vixen and daughter, and both vixens will raise lit- on the family territory. The male will g food to both litters, and the vixens, ead of competing, will tolerate each er. Why does the theory predict these nts? Because when food is abundant— sidering the genetic relationships in- ved—each fox will pass on more of his er genes to the next generation if mul- e litters are reared on the territory.

My field observations tentatively seem upport these predictions. In my study a, during years when prey was abun- t (one year, for example, there was a k in the snowshoe hare population), I occasionally observed two vixens ing separate litters several hundred ds from each other, and once, within same den. In both cases the vixens got along amicably and one dog fox brought food to all the pups. These observations suggest that the vixens were acquainted and may have been related. These preliminary data are interesting, but before we draw any final conclusions about this aspect of the fox's family life, more detailed research is needed.

During middle and late June, the pups' transition to adult life continues. They have grown to be nearly two-thirds the size of adults; they are fully coordinated and exhibit a bright red coat. During this period the parents start to visit the den less frequently, and the amount of food they bring starts to diminish.

At this point, as in many species, a classic conflict between parent and offspring arises. The fox kits appear perfectly content to remain at the den, play continually, and be fed by the parents. However, the adult foxes, which have been run ragged, seem to have some other arrangement in mind. And fortunately for them, they control the situation.

During June the pups wait endlessly for the adults to arrive with food. When an adult finally does appear, one pup gets the food, which he quickly consumes. Then the adult often takes one or several of the pups on exploratory trips away from the site. At first the parents lead the kits away and later accompany them home. But after a few of these excursions, the kits return on their own. I wish I could have gone along, but the parent foxes never tolerated me on the expeditions, and this aspect of fox life has always eluded me.

The kits, while hanging around the den, begin to eat wild fruit and to hunt insects and whatever other prey they can find. Gradually they become more confident,

venturing forth slightly farther each day and spending less time at the lair. Thus it seems that a combination of boredom and hunger eventually drives the kits away from the den site, whereupon they start a predatory, scavenging life of their own.

At first the pups travel in twos or threes. However, since the prey they hunt are small and quick, to capture one, the fox must hunt in a stalking, catlike manner using a surprise attack. These constraints slowly force the young foxes to become solitary predators.

Occasionally, the vixen and pups will rendezvous on the territory during late summer and early fall. When this happens, the foxes greet, play, and generally enjoy each other. By this point, however, the dog fox is intolerant of his cubs. During September, the male kits begin to mature sexually, and this increases the competition between father and son.

No one is certain what causes the kits to finally leave the territory altogether. Adult foxes have not been seen aggressively driving their young away, but they may exclude them from the best hunting and scavenging sites. Whatever the cause, during late September or October, the kits begin to disperse. Males leave first and travel the farthest. Each tends to travel in one direction until he has found an available territory. Once male kits have left their birthplace, they usually don't return. Female kits may remain on the family territory into December, and if food is plentiful, one or several female offspring may stay on.

Such is the way it happens. Each spring, kits are born; as helpless as embryos, they would freeze without their mother's constant attention. In the course of six short months, these tiny, helpless creatures grow into self-sufficient, graceful, flame-colored predators that leave their families and seek out their own part of the forest. When a young fox leaves, it becomes self-reliant and takes on the ways and manners of adults. It claims a territory and inhabits it with another fox—its prospective mate. During the frozen darkness of winter, the pair set up the territory and court, and the cycle inherent in a fox's life completes itself. □

These drowsing foxes have their second coat of fur—a sandy one—which matches the soil of the den site and therefore may protect them from occasional predators, such as owls, hawks, and coyotes.

Jen and Des Bartlett; Bruce Coleman Inc.

So Grows the Tree

The misshapen shrub at tree line may be the same species as the spire-shaped conifer farther down the slope. Are their differences more than bark deep?

by Jeffry B. Mitton

At ten thousand feet on the front range of the Colorado Rockies, subalpine fir and Engelmann spruce stand tall and upright—classic examples of the spire-shaped conifers of alpine forests. Just a little farther up the slope at tree line, however, individuals of the same species have a markedly different look. Here they are called flag trees, because their stems are often so pruned by severe winds that limbs grow only on the leeward side; trees at tree line also have dense skirts of branches encircling the stems near ground level. Even greater changes in tree shape are apparent higher up the mountain slopes in the alpine tundra, where the trees have a dramatically altered growth form called krummholz, or elfinwood. Those trees grow both upward and outward but are so pruned by drying winds that they spread laterally, forming prostrate shrubs. Branches on the leeward side often put out roots, while wind and windblown ice crystals abrade and erode the windward side; consequently, the trees grow and move downwind, leaving a trail of wind-carved "driftwood."

Biologists have long known that wind and other environmental factors determine what form a seedling will acquire. There has been debate, however, over whether these differences in shape are accompanied by genetic differences. For evolutionary biologists, who strive to understand the conditions that produce adaptive genetic change in populations, change that may ultimately lead to the emergence of new species, the resolution of this sort of debate is important.

Genetic experiments with such slow-growing and long-lived organisms as trees have rarely been carried out, however. (Some mature trees at our site may be as much as 700 years old, obviously impractical subjects for tracking through several generations.) And until recently, evolutionary biologists who wished to monitor genetic differences in populations could track only such visible traits as color and striping in land snails or colors and spots in moths and butterflies. Evolutionary studies were therefore restricted to species that were small (so they could be kept in laboratories) and that reproduced rapidly

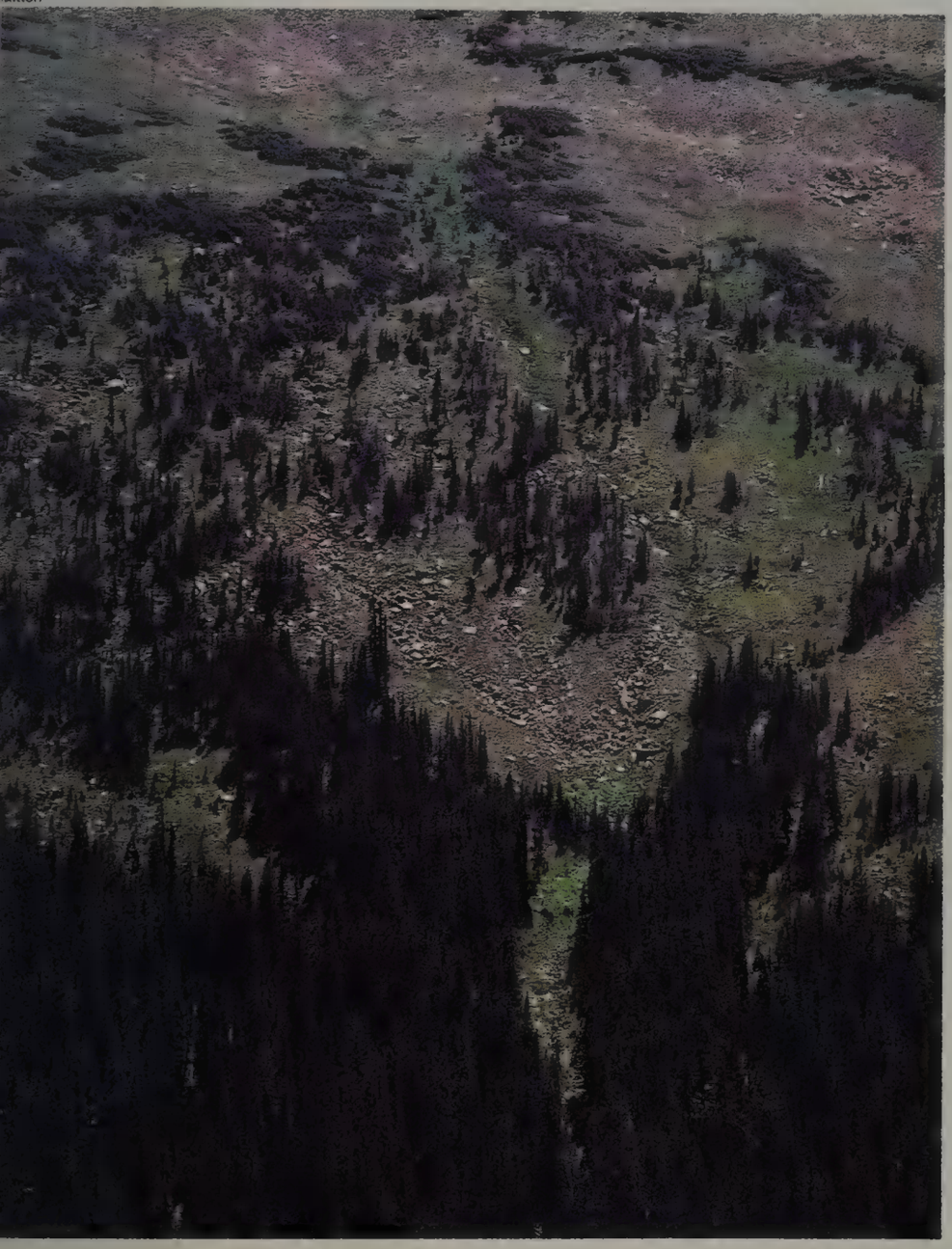
Extreme cold and severe winds at tree line (about 11,000 feet in the Rockies) force the normally tall, spire-shaped Engelmann spruce into a prostrate growth form called elfinwood, or krummholz. In this tundra region, the spring and summer growing season is only about forty-five days long, and many trees fail to produce pollen, seeds, or seedlings. In this event, branches touching the ground may put out roots, in an asexual mode of reproduction known as layering.

John Ward

d Pat Leeson

: Subalpine firs stand tall over huckleberry and mountain azalea
ıe relatively moderate environment below tree line. Below: Such
e-shaped individuals become scarcer with increased elevation,
ıually giving way to the low-lying krummholz.

Hitton



genetic variation could be watched
many generations). In the last few de-
es, however, techniques adopted from
ecular biology have enabled evolution-
biologists to study a much greater di-
ity of plants and animals.

)ne such technique, now in common
is electrophoresis. This laboratory
allows biologists to see genetic differ-
es among individuals by showing how
products of genes, the enzymes, differ.
enzymes are made of proteins, and cer-
genes are the blueprints for making
ific proteins. Remaining stable while
ıcing chemical changes in other sub-
stances, enzymes mediate myriad physiological processes essential to the growth and maintenance of all living things. When electrophoretic analysis is performed on a number of individuals in a single population, biologists can chart that population's pattern of genetic variation for a specific enzyme. It is not even necessary to know the enzyme's function. The beauty of electrophoresis is that it permits biologists to see, through enzyme staining, genetic variation that would otherwise remain invisible. This information allows an exciting, hitherto impossible look at the dynamic processes occurring within small geographic areas and within single generations, regardless of the size or generation time of the organisms being studied.

I have been using electrophoresis in the Rocky Mountains, attempting to discover some genetic pattern among the three growth forms (krummholz, flag, and spire) of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). These are the most abundant trees around tree line (approximately 11,300 feet) on Niwot Ridge, a mountain research facility maintained by the University of Colorado on the eastern flank of the Continental Divide in the Rockies. The climate on the ridge is challenging. Although summer temperatures may reach 85 degrees Fahrenheit, winter temperatures have been known to plunge to −37, and eighty-mile-an-hour winds are not uncommon. Permafrost can be found below the surface here, and the growing season—defined as the time between the last hard frost of spring and the first hard frost of fall—is seldom longer than eighty-one days and may be as short as thirteen days. Snow may fall any day of the year.

In this rigorous environment the distribution and shape of trees are largely determined by wind, temperature, snowpack, and sunlight. Winter winds sweep the snow from exposed ridges, and drifts more than fifty feet deep pile up in troughs. At our tree line study site, biologist Peter Wardle demonstrated that exposed parts of trees are dried out and eroded by wind-blown ice crystals. Limbs buried in the snow are protected from extremes in temperature and are sheltered from the wind; but if the snow cover persists long into the summer, the needles are attacked by snow molds and the photosynthetic tissue is destroyed. Thus, some trees are harried by too little snow, others by too much. In the very harsh environment at the uppermost limits of tree line, trees often fail to produce pollen, seed, or seedlings. Here some species persist by "layering," an asexual form of reproduction in which roots form from branches that touch the soil.

The influence of snow upon the distribution of trees is most clearly seen in the ribbon forests of the subalpine regions. The trees in these forests act as snow

fences, and seedlings do poorly in both the wind-scoured areas upwind of the fences and in the deeply drifted snow glades in the lee of the fences. The resultant forest is not continuous, but is composed of narrow stands of trees at right angles to prevailing winter winds.

In the krummholz zone, above tree line, seedlings need the protection to get established. Here, they are most successful in the shade of existing krummholz and shrubs. It may be surprising that seedlings and saplings need shade in this cool summer environment. In fact, too much sun is one of the common causes of death for seedlings: if the surface temperature reaches 130 degrees, the seedling's cortex, which transports water and nutrients, is destroyed.

To determine whether the morphological differences observable at tree line Niwot Ridge were associated with gene variation, Michael Grant and I used el trophoresis to look at peroxidases, en matic proteins in the needles of Eng mann spruce and subalpine fir. C samples included krummholz, flag, a the common spire-shaped individu within each species. The results were same for both species: there were subst

John Ward

All plants capable of surviving at tree line keep a low profile. Left: A cushiony patch of alpine avens blooms among the krummholz forms of subalpine fir and Engelmann spruce on Niwot Ridge. Below: Ribbon forests, long stands of trees that act as snow fences, are the result of the combined effects of snow and wind.

David L. Buckner

enetic differences among the three lations, and in each species the pro- ons of the different kinds of peroxi- in the flag trees were intermediate een those of spire-shaped and mholz trees. The disparities existed though the sampled tree populations within a few hundred yards of each , so pollen could move easily among ee types.

Unlike the morphological differences, which are both conspicuous and environmentally created, the enzymatic differences among the three populations are not only hidden but are also the result of real genetic differences. What causes and maintains such genetic variation? Could it be chance? Probably not, because windborne pollen and seeds can easily move among the three populations, thereby evening out the gene ratios. Perhaps the force is natural selection, but we do not know how the various peroxidases influence plant survival in these three environments. Peroxidases perform many functions, among them protection of tissues against fungal infection. One possibility is that the alternate forms of peroxidases exhibit varying degrees of protection against snow mold, and the frequencies of the particular peroxidase genes thus may reflect the degree to which the trees are at risk of infection from this fungus. Unlike the chance hypothesis, this explanation does not deny that pollen and seeds may move among the three growth forms, but rather it suggests that natural selection, through differential survival of trees of different genotypes, plays the dominant role in determining the pattern of genetic variation across tree line.

On a hillside near the University of Colorado, another species of forest tree, ponderosa pine (*Pinus ponderosa*), also exhibits genetic variation, but here the pattern does not seem to be produced by natural selection. Yan Linhart and I and our students have undertaken a long-term study

The closer a plant grows to the ground, the less it is subject to the pruning effects of wind and ice. Right: The sparseness of needles and branches on the tops of these wind-sculpted "flag trees" testifies to the difference a few feet can make. These trees are on an exposed ridge slightly below tree line.

Tom and Pat Leeson

of 217 trees on the south-facing slope that forms the entrance to Boulder Canyon. We are monitoring genetic variation, reproduction, and predation. Age, growth rate, and seven protein genotypes are known for each tree. The production of pollen and female cones, as well as the level of infestation by insects and the intensity of browsing by deer, has been followed for the last seven years.

As in many other stands of ponderosa pine, the trees on this hillside are not evenly spaced. They grow in six clusters, each cluster containing fifteen to fifty-four trees. Although the six clusters are all on the same hillside and appear to share the same environment, they differ in some important characteristics. Among other things, the clusters vary in cone production; in any year, one cluster may produce ten times as many cones as another cluster of similar size. And although all of the trees appear quite similar to the human eye, herbivores discriminate among them and exercise consistent choices: the extent of deer browse ranges from 30 to 50 percent from cluster to cluster, and the level of woolly aphid infestation ranges from 9 to 49 percent. These groups also differ in gene frequencies for several proteins. In this case, the trees are clustered by genetic affinities, but this pattern of genetic variation is not conspicuously associated with variation in the environment.

A historical perspective can help reveal what is responsible for the clustering pattern. Photographs of this area taken a century ago show a much lower density of trees. The present clusters appear to be offspring of one or a few maternal parents in a small area and of an unknown number of paternal parents from a greater area. Much of the pollen from any given tree falls within several hundred feet, but some grains may travel on the wind for many miles. Ponderosa pine seeds are also carried by the wind, but most land very near the tree that produced them, within a circle with a radius equal to the height of the tree. Thus, clustering of genetic characteristics on this hillside probably corresponds to loose family aggregations produced by highly restricted dispersal of seed.

Like the krummholz spruce and fir that live more than a mile higher in the mountains, ponderosa pines at this site exist in a very demanding environment. They cannot produce seeds regularly. In the seven years for which recorded data are available, the annual production of cones by the 217 trees varied from zero to 17,900. Since a mature, healthy cone produces an average of fifty good seeds, it would seem that the odds of a new seedling getting started are very good indeed. However, an analysis of the ages of the trees (by counting the annual rings from small cores extracted from their trunks) revealed that seedling establishment was highly erratic. Sometimes no seedlings were established for several decades. Then there are occasional years, apparently salubrious to pine seedlings, when many new trees began long lifetimes.

An accounting of cone production by individual trees reveals that seed production is not a random event. Although the number of cones produced varies tremendously from year to year, there is some pattern. In most of the years for which data are available, a minority of trees (about 10 percent) produced most of the cones (from 64 percent to 92 percent). This imbalance in the reproductive performance may present natural selection with an opportunity to act. Analyses of prot genotypes, growth rates, and cone prod tion reveal that these three variables interrelated. Ponderosa pines that re larly produce many cones typically hibit lower-than-average growth ra Trees with certain gene combinati grow more erratically from year to y but produce cones in more regular nu bers than trees with other gene combi tions. Such interrelationships of prot type, growth rate, and schedule of production could only have been disc ered in long-term studies of ecological netics.

Both plant and animal studies have b efited from electrophoresis. Biologists survey about one hundred enzymes for netic variation, and ecological gene studies have now been conducted American eels on the Atlantic coast North America, starfish living miles neath the surface of the ocean, salam ders living high in the trees of tropical r forests, and cheetahs from the plains Africa. With the tools now in hand to c duct rigorous and comprehensive gene studies of the ways in which populati adapt to their environments, we are nea than ever to looking directly at the co plex and dynamic processes of evolutio natural populations.

Bringi

A group of Inuit pose on board the schooner Era. *The ship's captain, George Comer, who served on whaling vessels in the Hudson Bay area of the Canadian Arctic, began taking photographs of Inuit life in the early 1890s.*

Mystic Seaport Museum

e Captain Back to the Bay

Photographs taken by a nineteenth-century whaling captain evoke memories among present-day Inuit

by Dorothy Harley Eber

"Quite often in the summer months we used to meet the Americans. You often heard people talking about them, so we knew who they were. They would be hunting for whales—beluga whales, bowhead whales—and walrus and polar bear hides.

"The Americans were mostly around Katitellik [Cape Fullerton]. They would winter there and then sail up toward Repulse Bay. My father was the man for the Scottish people so we didn't travel with the Americans—they had their own Inuit, Harry and his group—but I remember Captain Comer. We used to call him Angakok [the shaman] because he was able to take photographs. They would appear just like that, out of a piece of paper."

The speaker is Joe Curley, of Eskimo Point in Canada's Northwest Territories, born, he tells me, "not in the 1900s but in the late 1800s," when the Inuit (as the Eskimo here prefer to be called) pursued the bowhead whale from small boats among the ice floes for American and Scottish whaling vessels in Hudson Bay. His uncle and adopting father, Anutimarek, or Scotch Tom, was a chief of the Aivilik, the hunters who, for the fifty-five years (1860–1915) that constituted the whaling era in the bay, put their skills at the disposal of the foreign whalers. As we talk about those distant days and the personalities of the time, spread out on a table in front of us are copies of the photographs that gave Capt. George Comer, one of the great American whaling masters, the nickname by which he is still recalled up and down the west coast of Hudson Bay.

"He had a camera he would cover with a cloth," Curley continued. "He had glass negatives. He brought in various pieces of equipment and that's how he started taking photographs of the Inuit. People thought he was a shaman. An Inuit knows a shaman as a person who is able to make things appear or happen in a way no ordinary person can. If he had not produced these magical things they would not have called him Angakok. He didn't mind; Angakok was his nickname. But people didn't respect him so highly as a shaman that they weren't able to talk to him. They could have a normal conversation. They made friends with him and he used to eat amongst them. They favored him a lot."

In 1983, under the auspices of the Canadian Ethnology Service of the National Museum of Man, in Ottawa, I visited the new small towns on Hudson Bay's west coast, where the Inuit have made their homes since the erosion of the camp system. My purpose was to meet and interview descendants of the Inuit whalers, as well as the very few people still alive who, in their youth, sailed on the last of the whaling vessels. My talks were made possible by the bilingual generation of young adults who had attended school. For the interviews with Joe Curley my principal interpreter was a granddaughter, Madelaine Napayok Anderson ("At school English was my favorite; I like a proper past participle."). Later the tapes were carefully checked by Rosie Aggark, a daughter who works for the Interpreters' Corps.

In preparation for my trip I obtained prints of a number of Comer photographs. The captain had worked closely with Franz Boas, the "father" of anthropology, and had helped build up arctic ethnographic collections for a number of museums, including the American Museum of Natural History. According to Fred Calabretta, who made a study of the captain's life for the Mystic Seaport Museum in Connecticut (one of several institutions that hold important collections of the photographs), Comer began to use a camera in the Arctic as early as 1893. Calabretta has been able to locate at Mystic only two images definitely predating 1900; but hundreds of other photographs survive, taken in igloos, forecastles, and in all arctic weathers while Comer whaled with the *Era* (1897–1905) and the *A.T. Gifford* (1907–12). The task was not easy. In the *Era* journal for February 1, 1904, Comer wrote of the difficulty he experienced in photographing Inuit in the *Era* cabin: "The first flash light I probably did not fix right as it came near taking the roof of the cabin off—at least the report sounded loud enough to have done it."

As I visited the new Keewatin towns (the Keewatin coast borders Roes Welcome Sound, the principal Hudson Bay whaling theater), the photographs were al-

Captain Comer's picture-taking ability made him known to the Inuit as Angakok (the shaman), "a person who is able to make things appear or happen in a way no ordinary person can."

Mystic Seaport Museum

ways popular exhibits and provoked many stories. As informants told about spring whaling, about bringing ice blocks to the whaling vessel in winter, the scenes their words conjured up were often there, visible in the pictures.

Among my pack of pictures were many of people: groups, families, and especially images of a man and his wives. (In Comer's time most Inuit men had two wives. "Oh it was necessary for a great hunter—he needed two wives to work on his skins," one woman told me.) And many times I heard what good friends the wives in a family had been. "My grandmother used to joke with her husband-sharing partner about how, after they died, they must have their boxes close together. They had been great friends in life and wanted to stay together," another woman explained. Still another told of the additional hea break that followed the death of the m of the family. "My grandmother cr when my grandfather's other wife was ing to another family; they didn't wan be separated."

Most of the people in these poign studies were identified, but generally o by the names the whalers had bestowed them. "The people here would still rec nize their own relatives if their real nar had been used," I was told. Wrapp tongues around Inuit names was a pr lem for the foreign whalers, so they sorted to their own system of nomen ture, handing out common English nar (Charley, Mary, Harry) or names t identified helpers with specific ships captains or odd nicknames: Starbo Eye, Bye and Bye, John Bull, Jumbo, Stonewall.

Apparently perplexed by the sa problem, the Inuit, too, went in for nar calling. "The whalers weren't too fu about names in those days; so by w they were doing, so they were called, was explained. Physical characteristics ten inspired Inuit names for foreign The well-known Scottish captain J Murray, for whom Joe Curley's adopt father worked, was known as Nakuna (Cross-eyes).

While the names the foreign wha had bestowed often made it difficult learn about the sitters in Comer's ph graphs, fortunately, some of the nam perhaps the most unusual or those give the most distinguished Inuit whalers, w remembered. Some are still in use, so times in corrupted form.

Almost everyone was aware that Sh fly was the whaling name of Nivisena Comer's close companion, who alw traveled with the captain on shipboa The mere mention of her name spar lively comment wherever I visited up down the Keewatin coast. "Her capt gave her that name because she was ways shooing away the flies," an in mant explained. She was one of the wi of Tugaak, known as Ben, but liaisons tween Inuit women and the *kadl* (white man) were commonplace and cepted. Ben "knew the captain

f a number of photographs of Tom adopted when he was a little boy by r's Inuit companion, Shoofly, and d after the owner of the ship Era. *ortrait was entitled* Tom Luce at ller, July, 1905.

port Museum

enark as a girlfriend, but they were ood friends to each other." When lied, Comer recorded in his diary e helped with the burial. Shoofly ap- in a number of Comer's photo- s, sometimes identified, sometimes ut often recognizable by the two ificently beaded parkas she is known e worn.

Rankin Inlet I called upon Shoofly's daughter Bernadette Ookpik Pat- born about 1917, and her husband, oe's ancestors, too, were whalers; his worked for the Scottish captain Murray. Joe has a whaling name he ted—Coopie. It comes from coffee. ting a Scottish accent he says, be every morning the whalers would ut 'Coofie! Coofie!' "

nadette Ookpik, known as Ookpik ot her first name from French mis- ies), is the daughter of Shoofly's iological son, Oudlynnock, or as the rs called him, John Ell (from John llivan). John Ell participated in arctic expeditions and was said to be st known Inuit of his generation. He nd wrote English, played chess, and nd developed photographs. Inuit I to often referred to him as Comer's n and some declared he was Com- ctual son. Ookpik does not consider this likely. "Yes, my grandmother had a captain friend," she told me. "In fact she had pictures of the captain and used to receive presents of clothes and checks. But it was after John Ell was born that Angakok was living with Shoofly. My grandmother could bear no more children. She had to adopt them. John Ell had no *kadluna* blood. He was a true Inuit."

Ookpik and her husband are proud of the great reputation that Inuit hunters earned during the whaling years. (Up here they remember that the Inuit "caught more whales than the *kadluna*.") "I've heard," she says, "that some of the Inuit whalers were really good. In the whaleboat they used to have an Inuit for captain. The tradition was you'd take the man who had the most experience and let him be the leader."

Ookpik had her own picture of her grandmother and brought it out to show me. It was from a folio of old photographs of Inuit life published by the Northwest Territorial government; the photograph is not by Comer but by A.P. Low, commander of the Canadian government expedition vessel *Neptune*, which wintered beside the *Era* at Cape Fullerton in 1903–04. Picture-taking apparently enlivened the long winter.

In Low's shot, Shoofly's appeal is evident. She wears her long hair in laced braids in the manner northern educator George Diveky says indicates a woman has borne a male child. She is wearing her most famous *amoutik*—the women's parka with a pouch for carrying a baby—purchased by Comer in 1906 for the American Museum of Natural History. On the front, beside the designs of high-heeled boots and compasses, her name Shoofly (hidden in the picture by her braid), is embroidered in white beads. On the back of the parka, a kneeling hunter takes aim at a caribou. Low also photographed Shoofly with a group of women on the sleeping platform of an igloo. In this picture Shoofly is wearing a borrowed *amoutik*. An Inuit woman showed me a much treasured copy of this photograph that had been sent long ago to her grandmother and explained that Shoofly had dressed up for the camera in the grandmother's *amoutik*.

Ookpik told me that she had once possessed some parka decorations that had belonged to Shoofly. "My grandmother gave her *amoutik* decorations to her daughter-in-law. My mother had them, and later they were given to me. But they got lost. I actually had them, but at the time we were moving to the mainland from Southampton Island and we had to leave much of our stuff behind because we had only a small boat. I never saw them again. I heard they were given to an older person. All I can remember of those decorations are the bands for the sleeves. The beads came from the whalers, and it was the desire of every young girl to have an *amoutik* like that."

During an interview farther up the coast in Chesterfield Inlet (here in 1912 the Catholic oblates established the first mission among Hudson Bay Eskimo), I discovered that in our pack of photographs we had a picture of Shoofly's sister. Leonie Egalak Sammurtok exclaimed with delight when she found a photograph of a young woman identified only as Jumbo. "Jumbo! She was my aunt. Her Inuit name was Kognataluretuk." Jumbo was born into the same family as Shoofly but was then adopted into Egalak's family. "I used to see a lot of her," Egalak con-

Shoofly, who lived on board the Era *with Captain Comer, was also photographed by A.P. Low, commander of the Canadian ship* Neptune. *She is shown wearing an elaborately beaded* amoutik*—a parka with a pouch for carrying a baby.*

Public Archives Canada/PA 53548

tinued. "She used to be lots of fun. She was tall and very fat and her whole body used to shake because of her pounds. My grandmother and my mother used to tease Jumbo a lot because, compared with them, Jumbo was very fat. 'You should be slim, like us,' they used to tell her."

Looking at the beaded costumes in the photographs caused Leonie Egalak to remember a beaded parka she had worn the year before she began living with her husband. "I once had a costume with beads that was not quite a proper *amoutik* but that was rather heavy. It was before I had children. In those days the Inuit had various ways of making clothing, and just as little children would wear overalls we used to make a special parka for young girls that was not for carrying a baby. It was almost like the regular *amoutik*—it had all the regular fringes but it had a longer and the tip of this used to turn up in just to your heels. Later on when young woman began to bear children would get the proper clothing for carry a baby. I wore the parka only for a y then my mother asked the beads back my sister."

In Chesterfield Inlet, I was able to firm another important identification reasonable certainty. Viewing Com fascinating series of photographs take side igloos, a number of people, inclu a missionary, recognized Siatchiak important Inuit whaler known to the eign whalers as Bye and Bye) in one of photos. He had died in the mission's ho tal. W.O. Douglas, a sergeant in charg the Royal Canadian Mounted Police tion at Cape Fullerton, described Bye Bye's prowess in an article in *North* m zine about a whaling expedition with Eskimo skipper about 1919, after American and Scottish whalers had g "Bye n' Bye, I soon discovered, was perb whaling skipper. Bye n' Bye sho orders in a mixture of Eskimo, Eng and whaler jargon and every man did actly as he was told.... The skipp warnings about what he would do to one who made a noise were almost as t fying as some of the yarns I had h about the destructive power of a wh thrashing tail."

Within an hour, Bye and Bye and crew took two bowhead whales, an traordinary feat. "The whales were chored to the ice and cut up at the edg the floe.... I shall never forget the s of a man going down a ladder inside carcass and sending up pieces of heart liver with a block and tackle," Dou wrote.

Southampton Island is where man the Inuit whalers settled in the last da whaling, encouraged initially by Co who in 1908 left the greater part of Inuit crew to winter there. Today m descendants live in Coral Harbour, only community on the island. Kar Bruce is the granddaughter of Me ("the American") Aussaar, a nephe the Inuit chief Harry, who made draw and carvings for Comer. "He was no

tograph that Comer labeled
o Gals, caused present-day Inuit to
late that the two women might have
he wives of the Inuit whaler Uvinik.
omen are known to have been
in a whaling accident in 1913.
port Museum

ellow," Kanyuk remarked, looking mer's impressive photograph. Her nd, Mikitok Bruce, is a son of Tom who was adopted by Shoofly when a little boy. Named after the owner *Era*, Tom Luce was the subject of of Comer's most appealing shots.

"Angakok was a very likable man," ak told me, drawing on stories she eard. "He got his name because of otographs and because he had those echnical things that would wind up. here never used to have those me- al things. Every so often Harry was l to dinner with the Captain and n turn Angakok would share with uit and eat some seal meat."

ry, whose Inuit name was Ipatok ') Tasseok, appears in many of the graphs, sometimes with his Inuit on shipboard or in a snowhouse, mes alone wearing one of the plaid Joe Curley remembers as the type owned by those who worked for the cans. And Harry, along with his Powty, starred in a series of photo- s that showed the techniques sha- used in their contacts with the forces spirit world. In the whaling days ns were powerful indeed—"they summon a ship when people were ng"—and whaling captains had great respect for their powers. Although today the Christian Inuit sometimes do not like to remember or talk about shamans, most people found these photographs of considerable interest, and informants gave slightly differing versions of activities depicted. Looking at the picture of Powty lifting Harry's head with what appears to be a leather thong, Joe Curley said, "This person's head may become so heavy it is not possible to lift it. They will ask this person what his head contains—they will ask many different questions." Of the shaman tied in ropes, Curley said: "This person is tied up completely but because he is a shaman he will be able to free himself."

On seeing the same photograph, Joan Attuat of Whale Cove supplied some additional information. "Here you see there are witnesses watching to make sure the shaman tells the truth, that he is truthful about what he says he does. The person bound will have the witnesses with him at all times, to make sure there is no trickery. They will hold on to the rope that ties him."

After my visit to Coral Harbour, I began the journey back to Rankin Inlet, where I was to catch a plane out of the north. While there must certainly be Keewatin Inuit I did not interview who would

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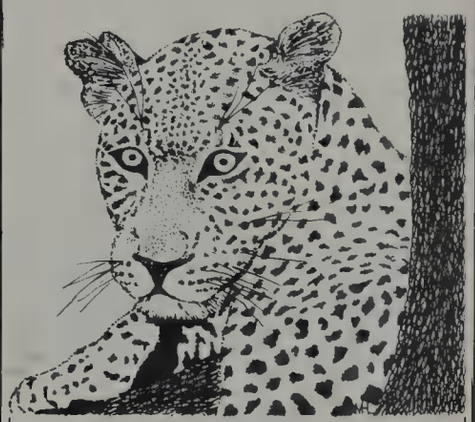

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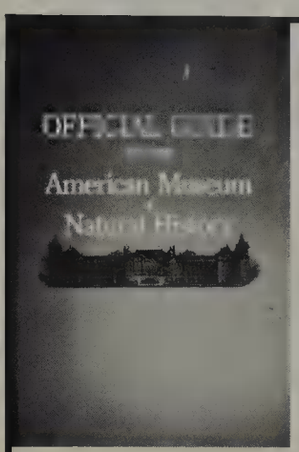

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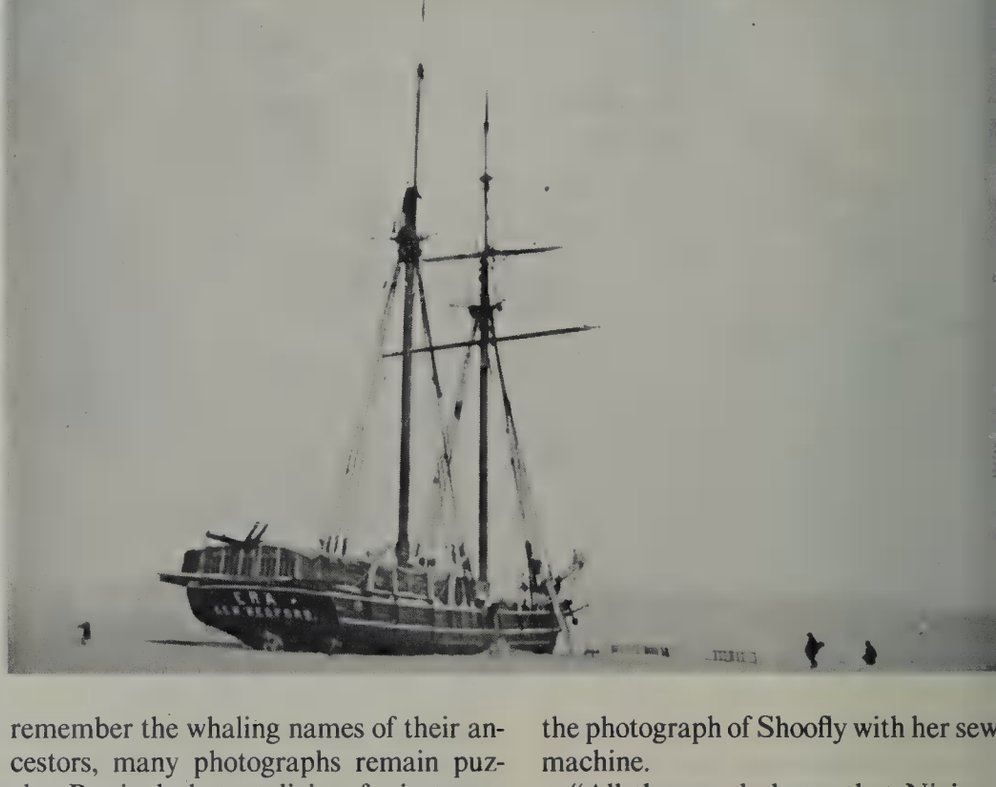
A starboard quarter-view of the whaling schooner Era *in the ice of the Canadian Arctic. Both American and Scottish whaling vessels plied the waters of Hudson Bay from 1860 to 1915, the years that constituted the bay's whaling era.*

Mystic Seaport Museum



remember the whaling names of their ancestors, many photographs remain puzzles. Particularly tantalizing, for instance, was a photograph of two young women and a child that Comer titled *Eskimo Gals*. "It's just my feeling," said Joe Curley, "that these are Uvinik's wives." Although there was no real evidence to support the identification, the photograph evoked a story of tragedy. Several of those who saw the picture wondered if the two beautiful young Eskimo women might be Hakaluk and Ikoak, wives of Uvinik, who were crushed to death in a terrible accident in the dangerous currents off Wager Bay about 1913. Many members of the family crew of the whaling boss Harry perished in this accident, and Uvinik, Harry's adopted son, later shot himself in his misery. The accident probably happened after Comer had departed from the north on his final whaling voyage, and it spelled a tragic end to the whaling days for Harry's Inuit crew.

In Rankin Inlet I saw Joe and Ookpik Patterk again and checked a few points with regard to the photographs. And on Ookpik's suggestion, I paid a call on Eugenie Towtoonee, a lively older person Ookpik believed would "have some historical material." Towtoonee had known Shoofly and was particularly taken with the photograph of Shoofly with her sew machine.

"All the people knew that Nivisen [Shoofly] was the first to use a sewing chine in the north. She was really g and could sew really well. She started s ing cloth material for friends and r tives—that's when we started using cl for clothes. I'm not sure what kind of cl exactly—I've heard she used to m dresses out of thin cotton. She used make them on the ship. The captain m have taught her how to make a pattern dresses and she started making dres and skirts. Maybe they had the cloth terial on Baffin Island or in the Ar Quebec region, but people remember t it was Nivisenark who started the clothing up here."

Shoofly is remembered as a pioneer trend setter in another sense, too. As the custom, she adopted a number of c dren. "Nivisenark bore only one child she adopted more children from other p ple," Eugenie explained. "Inuit ad children because they know they will g old and become sick. If her oldest son happened to die she would have had child to care for her; so she adopted so would have some support and help. adopted children who were half and h Probably she was not the only one

ed this kind of child but in our area
as the first to adopt the half-breed
en."
Inuit woman told me she believed
half-white babies were generally
and cared for, perhaps because "in
days so few children were being
However, in a letter to explorer
lmur Stefansson (now in the Ste-
n Collection, Dartmouth College
y), Comer suggested that while
children were fathered by white
rs, "there is not the affection for
by the Native Father that he has for
blooded child." In the dreadful fam-
nat sometimes occasioned cannibal-
order that the hunters might sur-
'children of the white man are the
be allowed to starve or perish."
ne of Shoofly's adopted children
with her on board ship, and after the
ng days were done it is remembered
he captain continued to send up
es and other little things."
ring my interviews I asked various
nants, descendants of the Aivilik,
the impact of the whaling years.
gave reasoned responses. Whalers
ht liquor, but they drank "not too
only a bit." They brought guns, but
nition sometimes ran out. Upon oc-
Inuit whaled so late in the fall that
ual preparations for winter were ne-
d; there was hardship, even starva-
But whalers had their virtues. They
t seek to dominate in the way Inuit
imes feel the present-day *kadluna*
s one informant said, "Inuit and
na worked together, helping each
" A young interpreter added, "They
establish power bases." "They were
good among the Inuit people," Joe
y declared.
he interview in the Stefansson Col-
n, Comer also left on record a com-
on the interaction between the whal-
d the Aivilik: "We got attached to
tives. . . . they have worked [among
halers] since Civil War times, and
g in contact with them has changed
tives. . . . Whalers perhaps have not
s been what they should be, still I
found them just as good as any other
e I ever met." □

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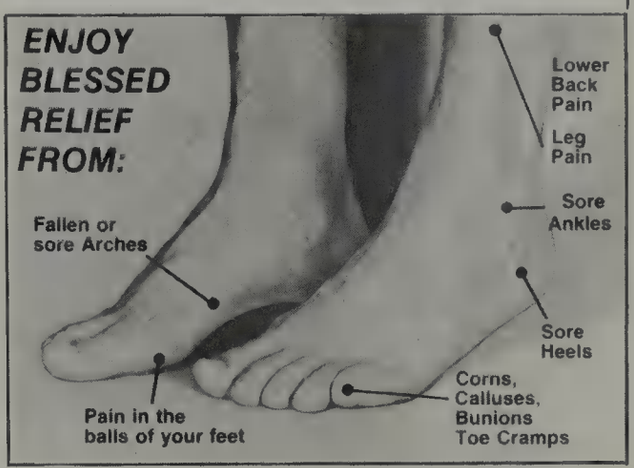

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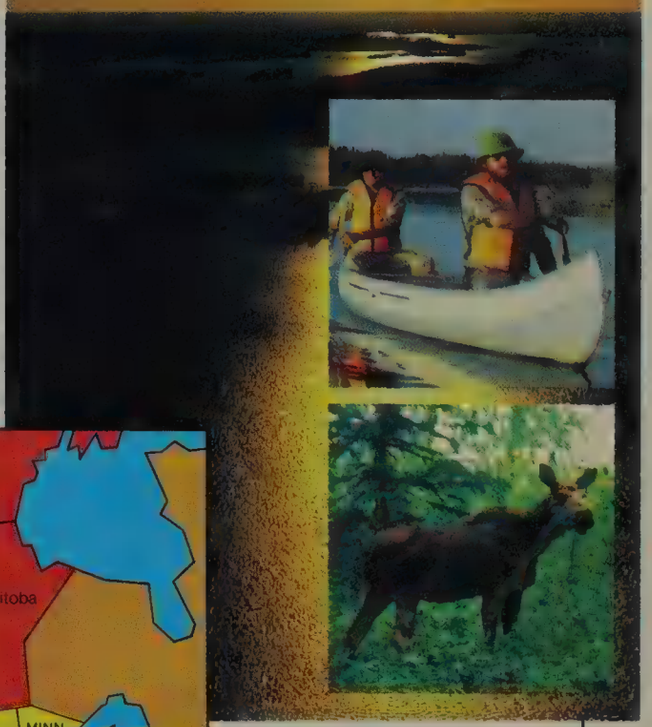

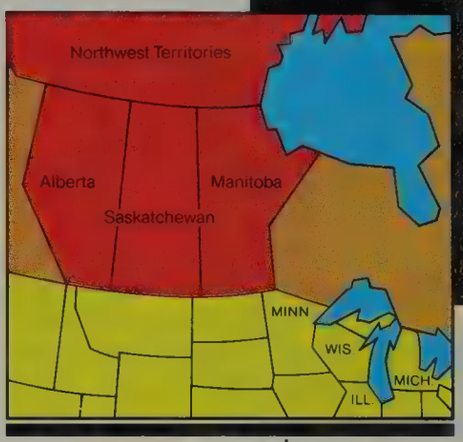

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THE NATIONS WITHIN: THE PAST AND FUTURE OF AMERICAN INDIAN SOVEREIGNTY, by Vine Deloria, Jr., and Clifford M. Lytle. *Pantheon Books, $11.95; 293 pp.*

Vine Deloria, Jr.! The name—to some contemporary white Americans—conjures up emotions similar to those raised in the nineteenth century by the names Geronimo and Red Cloud. For many years Deloria, with his pen (and now with his word processor), has struck terror in the hearts of snooping anthropologists, guilt-laden editorial writers, obtuse historians, and others who grapple with the contemporary or historical Indian, whether as an economic "problem," a literary symbol, or a political force.

The secret of Deloria's success in becoming the preeminent Indian spokesman is his inexhaustible energy, his wry good humor, his not inconsiderable scholarly gifts, and his diplomatic skill. Deloria has his detractors among Indians and whites, but his critics have had amazingly little success at shaking his self-confidence or denting his reputation. In the present volume, as in the earlier *American Indians, American Justice*, Deloria shares author credit with Clifford M. Lytle, his colleague in the Department of Political Science at the University of Arizona. The partnership, unequal though it may be, is fruitful. Lytle's participation seems to have added depth and responsibility to the sparkling, cynical, but often careless approach that characterized some of Deloria's earlier works, such as *Custer Died for Your Sins*.

There are two books here. One, sober and scholarly, deals with the Indian past; the other, imaginative and speculative, deals with the Indian future. The first "book" is a detailed consideration of the Indian Reorganization Act of 1934; the second deals with the recent and as yet not fully defined Indian struggle for a new identity. The two sections are appropriately joined under the felicitously chosen title *The Nations Within*, which signifies both the achievement of self-government under the Indian Reorganization Act and the current movement toward a national (and international) Indian identity.

The first part—a well-researched, general study of the bill that, under the guidance of Commissioner of Indian Affairs John Collier, completely reoriented the federal government's conduct of Indian affairs fifty years ago—does not seek to match the scholarly detail of earlier studies of Collier and the Indian Reorganization Act by such scholars as Kenneth Philp, Lawrence Kelly, and Graham Taylor. But while *The Nations Within* is popular and readable, it is not unscholarly except where the reader is asked to accept on faith the authors' attribution of motives. For example, the authors allege that Sen. Sam Ervin attached the Indian Civil Rights Bill to a fair housing bill in 1968 in order to kill the housing bill—a strategy that, if it did exist, was unsuccessful. This speculation is presented without any citation of authority or tangible proof. Some will accept the authority of Deloria on such matters because of the prominent role he played as executive director of the National Congress of American Indians from 1964 to 1967 and because of his influential role and continuing access to both Indian and white political leaders before and after his tenure as head of this organization. But such personal reminiscences are unreliable guides to the past; they smack too much of the journalist's shaky sources, which may be the raw m terial but not the substance of history.

In contemporary America the journ ist's role is often that of advocate, a Deloria and Lytle have too openly sumed this role. This is particularly tr when they move on to consideration o "movement toward nationality" on t part of Indian tribes.

Because special interest, sympathy, a guilt are inextricably mixed in all cons erations of the American Indian, it is di cult to obtain an unemotional, realist and impartial assessment of such a volat subject as Indian sovereignty. Desp their sophistication, the authors fall i the trap of judging John Collier's achie ment (in getting Congress to pass the dian Reorganization Act, which esta lished the legitimacy and defined t powers of Indian self-government as an tegral part of the law of the land) by ideal, rather than a practical, standa Collier is judged, not by what he wrest for the Indians from a sometimes u comprehending, sometimes skepti Congress, but by what he failed to obta such as a formal declaration of Indian litical sovereignty. Neither Deloria n other critics of Collier consider the prob ble fate that Collier averted: the total struction of Indian tribal identity and s ereignty. To say that Collier's legislati struggle "in most respects represented solid defeat" because the final version d fered radically from the original propo is to miss the forest for the trees.

The publisher claims that, in addition their analysis of the Indian Reorgani tion Act,

Deloria and Lytle trace the rise of Indi militancy and the decline of tribal gove

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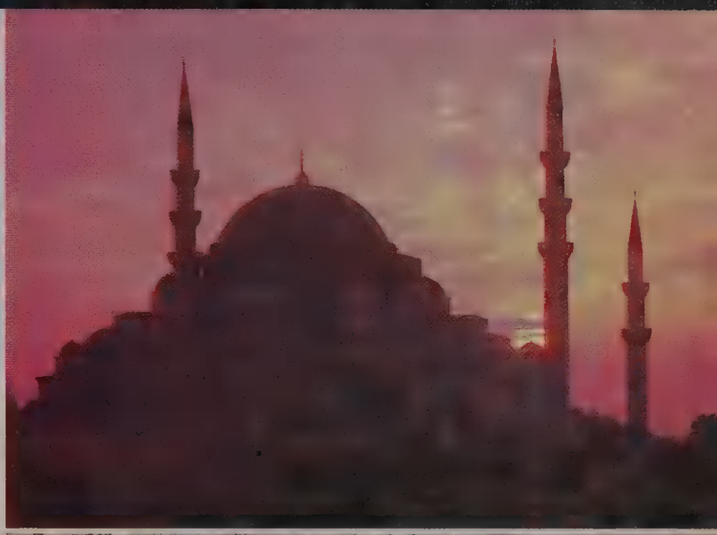

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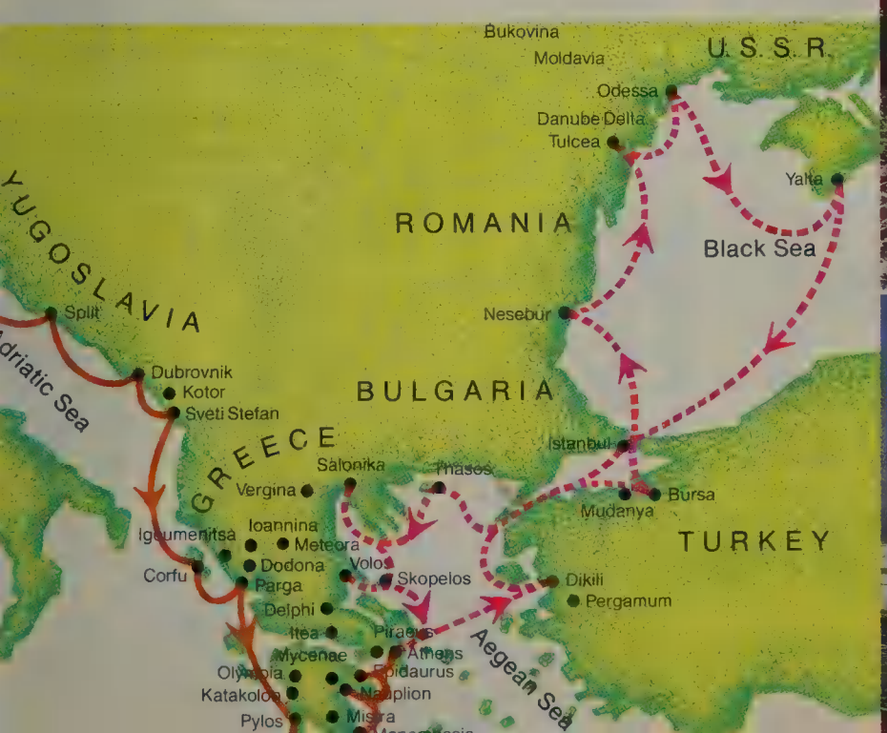

ment into near welfare-agency status, and show the political effects of Reagan's crippling budget cuts. They conclude with a set of sound proposals that take into account current economic realities while suggesting how traditional institutions can be used to resurrect sovereignty today.

Alas, if only publishers' blurbs would correspond to objective truth! Deloria and Lytle give a too-sympathetic account of the militant activities of the American Indian Movement (AIM) radicals at Wounded Knee and elsewhere, but fail to demonstrate that these actions have advanced the cause of Indian nationhood and sovereignty. The authors ignore the "work" of Leonard Peltier (about whom Peter Matthiessen wrote an entire book, *In the Spirit of Crazy Horse*, in 1983), the AIM activist currently in prison for shooting two FBI agents at Wounded Knee in 1973. Peltier has virtually become a patron saint of AIM, and his plight has been cited by the Soviet Union to blunt Western criticism of Soviet treatment of Andrei Sakharov.

Neither do the authors of *The Nations Within* do more than allude to the radicals' indictment of the United States for alleged crimes against humanity, such as genocide and sterilization of Indian women, before the Russell International Tribunal. Deloria is too honest a scholar and too sophisticated a politician to defend the radical Indian positions on s issues, which have little or no merit. he makes use of the radical rhetoric to press the vague hope of Indian lea such as himself for an evolution of In self-government into full Indian "nat hood."

Deloria is equally vague as to the pra cal steps that must be taken before In nationhood is achieved. He wistfully ludes to the "famous Twenty Points" which he was a principal author) sented to White House officials Leon Garment and Bradley Patterson du the 1972 election-week March on W ington. These points, which included toration of constitutional treaty-mak authority and the provision that all I ans be governed by treaty relations, v so totally out of touch with reality they had no chance of influencing the bate on Indian policy. After trashing Bureau of Indian Affairs (which now, cautionary measure, no longer exists separate, identifiable entity in Wash ton), the 1972 protesters and looters v provided tickets, at taxpayer expense return home. Had Collier not erected s a powerful protective shield around dian tribes by engineering the passag the Indian Reorganization Act, the w backlash that followed this ill-conce "protest" would probably have elimin whatever remnants of tribal self-gov ment had continued to exist.

Equally futile were the 206 recomm dations issued in 1977 by the Amer Indian Policy Review Commissio staffed almost exclusively by Amer Indians—whose principal recomme tion, as Deloria wryly notes, was for "n money." It seems never to have occu to the Indian leadership—such as it and is—that recommendations desig to wring power, money, and support f the non-Indian majority of the cou must have some relationship to poli reality.

Deloria and Lytle fail to provide cific recommendations for smoothing route from self-government to nationh The authors call for retention of In cultural values, reconciliation of facti elements within Indian communities, so on, but leave largely unspecified the ture of the Indian identity, economic tem, and political character that is pected to emerge. Recommendations phrased in party convention languag encompass everything, please every and offend no one. Thus Deloria and L assert that "relations between the t and the federal and state governm must be stabilized, and mutual res and parity in political rights must be

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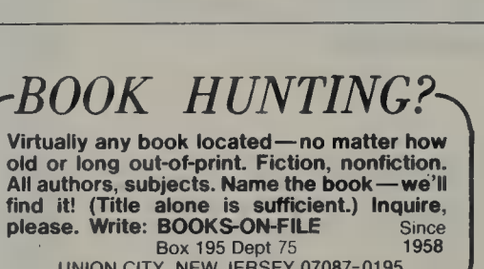
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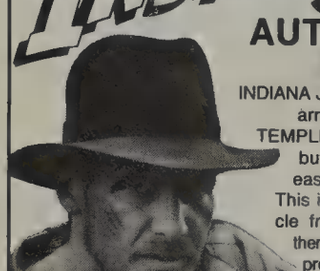
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d." Yet the authors are belittling references to the "government-to-ıent relationship" that underlies ıt Reagan's Indian policy. The au-sert incorrectly that "the ideology y adopted by Republican admin-ıs . . . makes Indians wards of the ıent. . . ."

ia and Lytle also seem to think calling something by a different ne creates a different reality. Call-bal council a national council does ximize tribal sovereignty (even if ands the membership) or cause it ercised "in a more comprehensive ." Calling policemen peace offi-es not constitute a "structural re-of the police function." Resolving differences between "traditional" odern Indian tribal governments be accomplished with pious plati-easy criticism of elected tribal of-Most curiously, the authors do not have a substitute for elective gov-t by majority rule, the bête noire of litionals and radicals.

n claims against the U.S. govern-djudicated by the Indian Claims ssion, Court of Claims, and the upreme Court, constitute particu-nsitive issues among Indian lead-ers. Of all the land claims, the Sioux claim is the most famous. The Sioux are still divided on the question of whether to accept the 1980 Supreme Court decision replacing a series of earlier judicial determinations of the amount of compensation the United States owes the Sioux for the taking of the Black Hills over a century ago. Deloria, a Sioux, does not tell us where he stands on the issue, preferring instead to straddle it. As he notes, "Claims are both satisfying in terms of fulfilling ancient promises and disruptive in that they take an inordinate amount of time and energy away from other reservation activities that would be more profitable in the long run."

When all is said and done, Deloria and Lytle, while not providing a practical solution to the Indian future, have laid the basis for a more mature consideration of that future by Indian tribal leaders. They have done this, first of all, by providing a well-written and basically accurate consideration of the Indian Reorganization Act. They grudgingly give John Collier credit for what he did accomplish, even while chiding him for not doing more. Secondly, they recognize that the act is the fundamental and indispensable foundation on which the movement toward Indian nationhood, if it is ever to occur, must be built. Thirdly, they point out that a successful movement toward nationhood for all Indian tribes must be sustained by rhetoric that is pro-Indian rather than anti-white. "Self-determination involves having a responsible group that has pride in itself but does not generate this pride by pointing out the shortcomings of other groups."

The Nations Within takes a significant step toward creating this responsible approach. Whether the Indian nations will achieve the full extent of the sovereignty that the authors visualize is, however, doubtful.

Wilcomb E. Washburn is director of the Office of American Studies at the Smithsonian Institution and the author of a number of books on the American Indian, including The Indian in America *and* Red Man's Land/White Man's Law.

Erratum: An incorrect credit line appeared with the reproduction of Claes Oldenburg's "Proposal for a Cathedral in the Form of a Colossal Faucet" (November 1984, page 20). Permission to reproduce was granted by the Whitney Museum of American Art.

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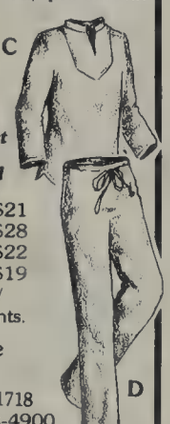

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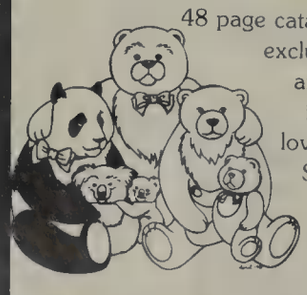

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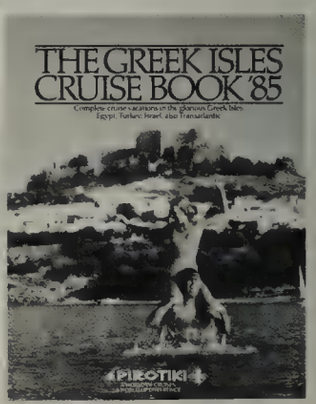

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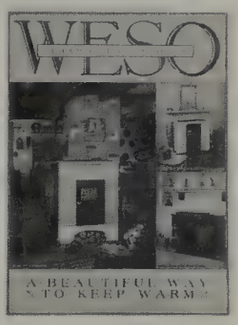

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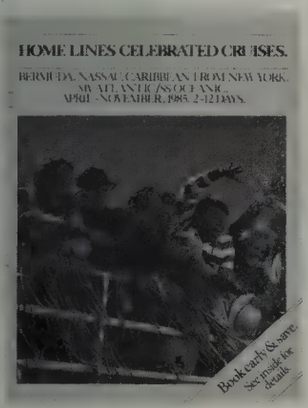
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Venus Shows Off

by Thomas D. Nicholson

After months as a not too prominent evening star (bright enough but not well placed in the sunset sky), Venus is now glorious in the west after sundown, visible for nearly three hours. It improves as it goes past its greatest easterly elongation toward greatest brilliancy in late February, so we have a number of weeks of good viewing ahead of us. Mars, Jupiter's companion of November, is now near Venus, and both nearly keep pace as they move left through the stars this month. But Mars does close slowly with the brighter Venus. After dark each night, while Venus is still up in the west, look below it for Mars, the only bright object nearby. Watch throughout the month as it moves toward Venus. They will be especially prominent near the moon on the 24th.

Jupiter goes over into the morning sky at mid-month when it passes conjunction with the sun. Saturn improves as a morning star in January, rising about three hours past midnight at mid-month, well up in the southeast by dawn. It is in Libra, to the right and above Antares, the bright reddish star of Scorpius. The moon guides you nicely to that star on the morning of the 17th.

Events in the calendar below are given in local time unless otherwise stated.

January 1: The early evening moon, in Aries and about two days past first quarter, lights the sky until after midnight.

January 3: Mercury is at maximum distance to the sun's right, favorably located as a morning star low and to the right of the rising sun before dawn for the next two weeks. The earth is at perihelion, nearest the sun.

January 3–4: Aldebaran, in Taurus, is below the moon both evenings. Nearby are the V-shaped Hyades and the fuzzy patch of stars called the Pleiades, both dimmed somewhat by the moon's light.

January 6: Full moon is in Gemini. The twin stars to its left are Pollux and Castor; Orion's prominent stars and the two Dog Stars stand out below in the bright moonlight. The latest sunrise of the winter occurs today; morning light will brighten noticeably earlier in a few days.

January 9: The moon and Regulus, Leo's bright star, rise nearly together, climbing up the eastern sky before midnight. But the moon rises nearly an hour later each night and Regulus rises four minutes earlier.

January 11–13: The moon spends these three nights in Virgo, at perigee (nearest the earth) on the 11th; last-quarter phase on the 13th will be at 6:27 P.M., EST. It steadily approaches Spica, the brightest star in Virgo, passing above it on the evening of the 13th, when both rise at just about midnight.

January 14: Jupiter ends its recent reign as an evening star and technically becomes a morning star when it passes the sun (conjunction) today. It will reappear in our sky in a few weeks.

January 16–17: The late crescent moon now belongs to the morning sky, joining the stars and planets to the sun's right. It is close to Saturn before dawn on the 16th and to Antares—Scorpius's bright star—on the 17th. When it nears Jupiter on the 20th, however, both will rise only a few minutes before the sun, excluding any chance of our seeing them.

January 20: New moon, at 9:28 P.M., EST, is in Capricornus.

January 21: When Venus reaches greatest easterly elongation (maximum distance to the sun's left), it is best as an evening star. But not all elongations are equally favorable. Today's is a good one, if not the best. Venus is high and bright in the sunset glow and early darkness for several hours; the dimmer, ruddy-looking object near it is Mars. Venus's evening appearance can be enjoyed from now until mid-March, when it sets too soon after sundown for successful viewing.

January 22: The new crescent moon should surely be visible if the sky is clear tonight after sundown. High and to the sun's left, a slender crescent of sunlight bounces off its right side. Over the next several nights, it will move closer to Venus and Mars, above to its left, as the crescent grows thicker.

January 24: The moon passes below Venus and Mars in the early evening, making for a pretty sky if the weather lets us see it. The two planets are above the moon to its left. After the moon passes Venus (about

7:00 P.M., EST), it moves slowly to the left (but fast enough for viewers to notice the change in about half an hour) between the two planets until it passes Mars about four hours later.

January 25: The crescent moon is at the border between Cetus and Pisces. The star below to its left is Diphda (in Cetus); Pegasus (note the large "square") is above and to its right.

January 27: Apogee moon (farthest from the earth) is in Pisces.

January 28: First-quarter moon (at 10:29 P.M., EST) is in Aries. The star above it is Hamal, the brightest in Aries.

January 30: The gibbous moon is between the Pleiades (to the right) and Aldebaran (the reddish star to the left), all in Taurus.

January 31: We won't notice it, but Mercury passes Jupiter (a conjunction) today. Both morning stars rise too late in the dawn to be visible. The evening moon is above Aldebaran. Look along the right side of the V of stars (the Hyades), which includes Aldebaran at its tip, past the moon to El Nath, the star marking the Bull's left horn.

The winter Sky Map shows the sky for the months of January, February, and March, as viewed from latitude 40° north at the evening hours given below. To use the map, hold it vertically in front of you with north (N) at the bottom and match the lower half of the map with the stars you see when you face north. As you turn in other directions roll the map to bring the compass direction you face to the bottom of the map.

The stars move west slowly during the night. By morning (before dawn), stars on the western half of this map will have set, those on the eastern half will be in the west, and new stars (those of the spring evenings) will have risen in the east. The map represents the sky at about 2:00 A.M. on January 1; 1:00 A.M. on January 15; midnight on January 31; 11:00 P.M. on February 15; 10:00 P.M. on February 29; 9:00 P.M. on March 15; and 8:00 P.M. on March 31. The map can be used for an hour or more before and after the times given.

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The Comet That Woul

A satellite telescope has found a strange object that may be the long-sought missing link between comets and earth-crossing aste

by Stephen P. Maran

As the famed Halley's comet approaches, to appear in the sky in autumn of this year and the spring of 1986, the accompanying hoopla might easily obscure the fact that a number of other comets, many of comparable scientific importance, are also under study. On the first of January, Halley was still almost 404 million miles from the earth, a long way from its projected position in March 1986, when a fleet of European, Soviet, and Japanese spacecraft will sweep past it, taking photographs, spectra, and measurements, and when U.S. astronauts will pilot a space shuttle payload of powerful telescopes to observe it from the earth's orbit.

Meanwhile, other comets and related objects are undergoing concentrated study. One notable example is Comet Giacobini-Zinner, which on September 11, 1985, will be intercepted by NASA's International Cometary Explorer (ICE) space probe. Another is a recently discovered object called 1983 TB, which, although classified as an asteroid, follows the path of the Geminid meteoroid stream (the tiny objects that produce the Geminid meteor shower on Earth each December) and is almost surely a dead comet.

To brush up on nomenclature, a comet is a celestial body consisting of a solid nucleus (a few miles or less in diameter) that, as it approaches the sun, develops a surrounding atmosphere (the coma, tens to hundreds of thousands of miles across), and one or more tails. The tails may extend for a hundred million miles or more. A meteoroid is a rock or dust particle outside the earth's atmosphere in interplanetary space. Falling through the earth's atmosphere, a meteoroid is heated by friction that makes adjacent air molecules glow, producing the short-lived streak of light called a meteor, or "shooting st meteoroid that lands on the earth face is called a meteorite. A large n of meteors seen during a short tim (from hours to days) and all arrivin nearly the same direction is know meteor shower. (The most pron showers are the Perseids, which a about August 12 every year, an Geminids, which occur about Dec 14.) The huge collection of meteoro biting the sun, which produce a giv teor shower, is called a meteoroid s

Meteorites are chunks of rock an but they don't seem to come from m oid streams. Instead, they are appa fragments of asteroids, the solid that range from big rocks to tiny p and are confined mainly to the as belt between the orbits of Mars and ter. Asteroids differ from comets i they lack atmospheres and tails meteoroids involved in meteor show *not* chunks of rock; they appear to b fluffy dust particles. Some have ac been captured by U-2s and other su equipped, high-altitude jet aircraft ther, these meteoroids seem to com comets. The nucleus of a comet, acc to the famous dirty iceball theory, c of water ice and various frozen gas terspersed with dust particles. As t zen material at the surface of a com cleus evaporates under heating by t and turns into gas, the outward-stre gases blow the dust previously trap the ice back from the head of the co the direction opposite the sun, th forming a dust tail. All of the matter dust tail is subsequently lost to the forever as the tail streams backward the head. The lost dust gradually fi space around the comet's orbit in a

embles a stretched-out doughnut
because most comet orbits are
longated ellipses).
the earth, traveling its own
circular orbit around the sun,
through the stretched-out dust
ut of a comet, the dust particles
wn through the earth's atmo-
producing a meteor shower. There
ubt that this explanation of meteor
is correct, because there are clear
ions between the orbits of various
id streams and the orbits of cer-
nets. For example, there are two
meteor showers associated with
doughnut of Halley's comet, the
uarid meteors, which appear in
lay, and the Orionids, which ap-
out October 21.
the above, despite the confusing
logy (even comet and meteor ex-
suse some terms about as often as
them correctly) have made up a
nt story that is found in any num-
stronomy textbooks. The only fly
intment has been the case of the
ossing asteroids (often called the
and Amor asteroids). The sugges-
been made that they began their
comets rather than asteroids, even
as mentioned above, most evi-
dicates that comets and asteroids
lly different types of objects. Like
steroids, the Apollo and Amor
pear to be hunks of rock, but, as
rossing" implies, they are not con-
the asteroid belt as are the great
of known asteroids. Instead, they
h or even pass within the orbit of
h. Geophysicist George W. Weth-
ector of the Department of Terres-
agnetism at the Carnegie Institu-
Washington (D.C.), has main-

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tained for years that the earth-crossing asteroids are not visitors from the asteroid belt but comets that have somehow lost their vital powers and can no longer produce a coma or a tail. This theory attracted much favorable attention in the past, although none from me. As an ardent believer in the dirty iceball theory of comets, I found it hard to imagine an iceball turning into rock. Sketches in some astronomy books do depict a big rock, beneath all the ice, at the center of a comet's nucleus, but there has been no direct evidence that such rocky cores actually exist. My concept of the death of a comet has always been that repeated bouts of solar heating, as a comet makes numerous orbital passes around the sun, turn the dirty ice into outflowing gas and dust and gradually lead to the comet's complete dissolution.

There are some meteor showers for which the parent comets have not been identified. Such was the case, until very recently, of the Geminid meteors. As recently as February 1983, three British meteor experts at Queen Mary College in London and the University of Sheffield commented that the parent comet of this meteor shower "has not been detected and . . . . probably completely decayed a long time ago." Thus, they seemed to share my feeling that comets are gradually reduced to nothingness. However, by December 1983, when the article in which this comment appeared was actually published, those three British scientists had made an important addendum: they noted that the parent comet had apparently been found, in the form of object 1983 TB.

Comets are usually named for their discoverers. Comet Kohoutek was named for Lubos Kohoutek, the Czech astronomer who found it, and Comet IRAS-Araki-Alcock (see "Thereby Hangs a Tail," *Natural History*, June 1984) was named for the Infrared Astronomy Satellite (IRAS), which discovered it, along with codiscoverers Araki and Alcock, in Japan and England, respectively. A famous exception to the rule is Halley's comet, named not for its discoverer (no one knows who that was) but for the English astronomer who first predicted in the early eighteenth century that the comet would return. When an asteroid is discovered, it is given a temporary designation consisting of the year of the discovery and some letters. Eventually, an international commission will name the asteroid, usually after anything or anyone but the discoverer. Thus, when IRAS found a previously unknown earth-crossing asteroid in November 1983, it was named 1983 TB.

Soon after its discovery, observations of 1983 TB made with ground-based telescopes at California, Hawaii, and elsewhere showed that it lacked any hint of an atmosphere or a tail, confirming that it should be classified and named as an asteroid. However, the computed orbit of 1983 TB is almost the same as that of the Geminid meteoroid stream, and since we know that meteoroid streams consist of dust from comets and cause meteor showers, there is a good possibility that 1983 TB is the long-sought parent comet of the Geminid meteors. Somehow, as Wetherill, the Carnegie geophysicist, had long maintained, an icy and dusty comet seems to have been transformed into a presumably rocky asteroid, lacking both an atmosphere and a tail.

The orbits of 1983 TB and the Geminid meteoroid stream are so nearly alike that almost any astronomer would be convinced of a causal association between the asteroid and the meteoroids. And 1983 TB has other unique properties that tend to support its identification as the missing link between comets and earth-crossing asteroids. For example, as an asteroid (so classified because of its lack of atmosphere and tail), 1983 TB comes closer to the sun than any other known asteroid, while as an inactive comet (producing no outpouring of gas and dust), it has the smallest orbit of any known comet.

I should mention that there have been previous accounts of purported missing links between comets and earth-crossing asteroids and between asteroids and meteoroid streams. However, the earlier evidence has never been persuasive.

Personally, I am convinced from its orbital characteristics that 1983 TB is the asteroidal or asteroidlike remains of the comet that produced the Geminid meteor shower, but as of this writing (October 1984), no solid supporting evidence for that belief has been cited. Asteroid and comet investigators Anita L. Cochran and Edwin S. Barker, of the University of Texas in Austin, obtained spectrograms of 1983 TB with the 107-inch telescope at McDonald Observatory near Fort Davis, Texas, and found no trace of emission from cometary gases. Photographs made at Palomar Observatory in southern California show no hint of a coma or tail. Infrared measurements made with NASA's 120-inch Infrared Telescope Facility on Mauna Kea, Hawaii, by Glenn Veeder of the Jet Propulsion Laboratory, have been combined with other data to determine the diameter of 1983 TB. Veeder reports that the diameter is about three to four miles, comparable to the size of most earth-crossing asteroids but large compared to the estimated diameters of the nuclei of most observed comets.

Lacking supporting evidence fo identification of 1983 TB as an old tive comet, we have to ask if there way, consistent with the known facts it could be just a plain asteroid. O swer is as follows: Although all mete streams are thought to be debris comets, a possible collision betwee asteroids might produce a sufficient ber of small particles of debris to cr phenomenon resembling a mete stream. Such a collision would be time event, so the stream would not long as the debris shed by a comet, persists for hundreds of thousands o millions of years, as the comet keeps ding each time it passes the sun. Re sightings of the Geminid meteor s have only been reported since 18 contrast to other meteor showers see ularly since antiquity. Further, cou the occurrence rates of the Geminid ors show that there are strong variati the number of meteoroids withi Geminid stream's orbit. This suggest the meteoroids have been shed by th ent object, 1983 TB, in the relative cent past and are not debris that acc lated over the millennia. These two may be consistent with the putative of the meteoroids in a collision be 1983 TB and another asteroid, but are probably good counterargument balance, since other meteoroid st are definitely associated with comet none are associated with other aste the case that TB is a dead comet is ger than that the Geminid meteoroi debris from an asteroid.

Short of visiting and inspecting 1983 TB, the best way to verify th clusion that comets evolve into crossing asteroids would be to id other likely examples of such an evol Astronomers are earnestly pursuin line of investigation. In fact, the word on the earth-crossing aste Oljato suggests that it too may be an tive comet. Lucy McFadden, an inve tor of asteroids at the University of land in College Park, reported October 1984 meeting of planetolog Honolulu that Oljato reflects sunligh "distinctly non-asteroidal" manne that it reflects radar transmissions the earth in a way suggestive of "a v regular, if not grotesque shape." that be the shape of a comet nucleu has lost its surface deposits of ice? also seems to interfere with the solar in a manner suggesting that unseen d similar to the debris in a comet tail, behind it.

Studies of 1983 TB and other crossing asteroids are of special in

space probes will probably begin
hese objects in the not too distant
nd we need to know what to ex-
ie suggestion has even been made
ure astronauts or robot space vehi-
ght mine these asteroids for useful
ls. There has been much discus-
uch missions in the United States,
ecent report from the Central Re-
Institute for Physics in Budapest,
y, by well-known Soviet and Hun-
physicists describes methods of
g the surface of an asteroid by
rding it with particle and laser
from a nearby space probe. Thus,
ssians are also thinking about a
ight to a nearby asteroid. In view
is, we would like to know beyond
ble doubt whether the earth-cross-
eroids are the remains of comet
or are big hunks of rock.
nope is that future investigations
nfirm whether, as I now believe
pologies to the late Gen. Douglas
thur), "old comets don't die, they
e away."

*n P. Maran is a senior staff scien-
he Laboratory for Astronomy and
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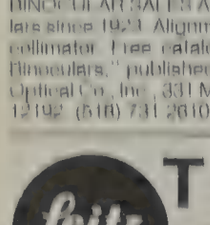

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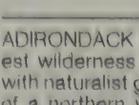

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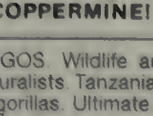

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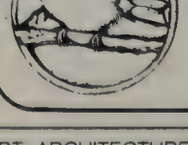

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A Delectable Drupe

Both political upheaval and tax breaks have influenced the success of the American pistachio nut

by Raymond Sokolov

Somebody must have forgotten about Steven K., for that exuberant tyke rampaged without supervision in our basement rec room one afternoon in the fifties, spreading expensive pistachios and red-stained finger marks everywhere. He had been driven into a frenzy by his inability to open most of the nuts. Cleaning up after him was a major job, but I can now look back benignly on the chaos he caused because it is unlikely to be repeated. These days red-dyed pistachios are scarcer, the price of all pistachios is falling, and their shells are easier to open, less frustrating to tots and grown-ups alike.

Probably no foodstuff has gone through more thoroughgoing change in the last decade. Events and influences as widely scattered as the fall of the shah of Iran and the installation of an aqueduct in California have turned the exotic pistachio nut into a booming American crop, perfected botanically, harvested by the latest techniques, and launched by a tax loophole.

The pistachio began as a wild tree, probably in Asia Minor, where Neolithic peoples latched on to its grapelike clusters of red-hulled fruit and learned to like the meat they found inside the hard ivory kernels. Carbonized nuts from Stone Age settlements excavated in Jordan and Turkey have been dated to about 7000 B.C. Between that time and the 1970s, people spread *Pistacia vera*, a smallish, twenty-five- to thirty-foot deciduous tree, around the Mediterranean. Iran became the world's pistachio leader, with production centered in the Kerman region, also known for its rugs.

For the pistachio, botany was destiny. Like the peach, the pistachio is a drupe; its hull surrounds a hard-shelled kernel, with a crunchy, oily green or yellow "nut" inside. In fact, the pistachio is a memb
the same family, Anacardiaceae,
two other drupes of great economic i
tance, the mango and the cashew. T
the relationship between them gr
cally, cut open the stone of a mang
note the cashewlike nut hidden there
tachios do not look anything like cas
but certain varieties have a turpentin
vor also common to some strains of m
and to all unripe mangoes. In
Pistacia terebinthus, a cousin of the
chio of commerce, is the original sou
turpentine.

In most parts of the world, the nuts
vera are still harvested and processe
hand. The red clusters are left to dry
sun and then, at a later, more conve
time, soaked in water to facilitate
hulling. The defect of this method, ev
countries like Iran where labor is che
that it allows the pigment of the h
stain and mottle the shells. Now if
chios were sold as naked, sh
nutmeats, this would make no differ
But they are almost always roasted
salted in the shell because, ideally
usually, they emerge from the hull "
ing," with their shells split at one end,
for the eater to shell on his own. Since
are small as nuts go, the producer de
an enormous advantage from selling
unshelled. You could say, moreover,
the pistachio nut is a naturally pack
convenience food, protected from
by its shell, but relatively easy to
(This is not always true. A certain per
age of the nuts do not split and are a
to dentists with pistachio fanciers in
practice. One of the main aims of mo
pistachio culture is to develop cul
that grow fewer or no unsmiling, c
nuts.)

sk the mottling left from dilatory,
oned processing, traditional pis-
erchants dyed their nuts red. Un-
ed nuts were sold in their natural
t most Americans came to know
chio as a red nut sold in vending
s. And most of these nuts used to
om Iran, where a tree said to be
s old still stands as a symbol of the
most important pistachio crop.
today, the pistachio is a crucial
ent of Iran's economy. Pistachios
roughly half of Iran's nonoil ex-
enue. Iranian tourists, who travel
to spend blocked Syrian currency
o them as part of a program of re-
for Syria's Iranian oil bill, get off
e in Damascus toting bags of pis-
which they sell for hard currency
eet. In Dubai, there is also a brisk
ade in pistachios carried in by
om Iran. A more official pistachio
ce goes on with Europe, where the
e of Iranian pistachios currently
nem competitive with California
os grown in the land of the high-
ollar.
n this country, the Iranian crop
ugh sledding for the first time in
To a certain extent, the rise of the
fundamentalist regime of the
h Khomeini has undermined
merican pistachio sales. As Albert
of the pioneering American pis-
distributors Zaloom Bros. in
s, New Jersey, puts it: "The nor-
ern of business with Iran has been
d. The traditional merchants have
ere's no such thing as orderly com-
ran is a controlled economy run
hs. This year they shipped a huge
here even though they knew that
ia had a bumper crop."

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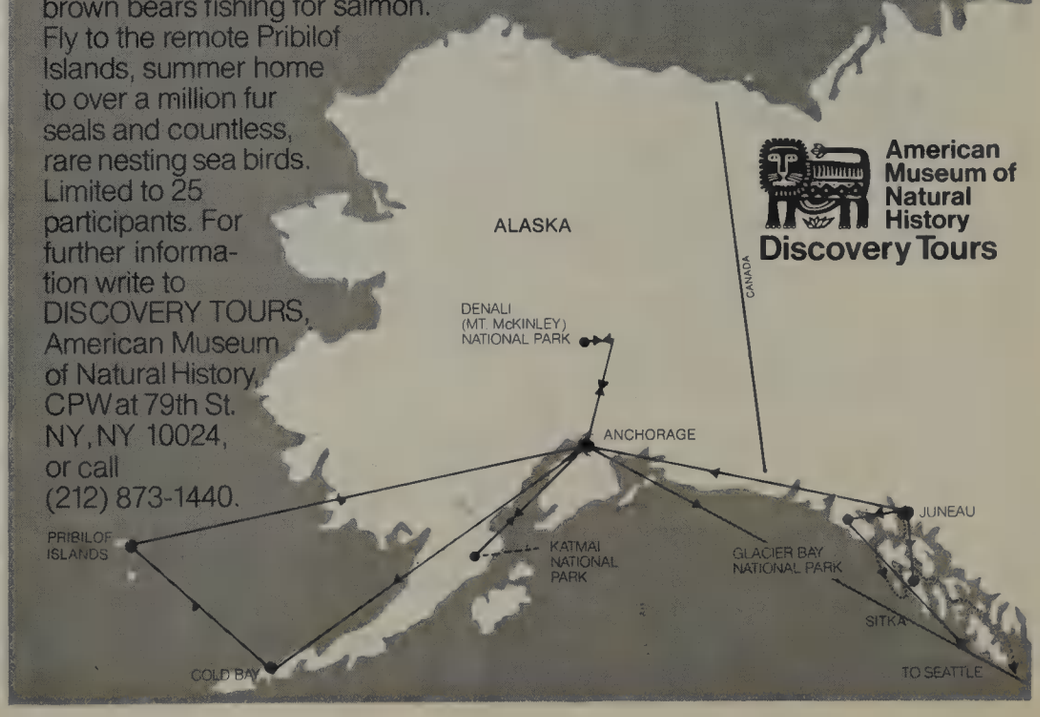

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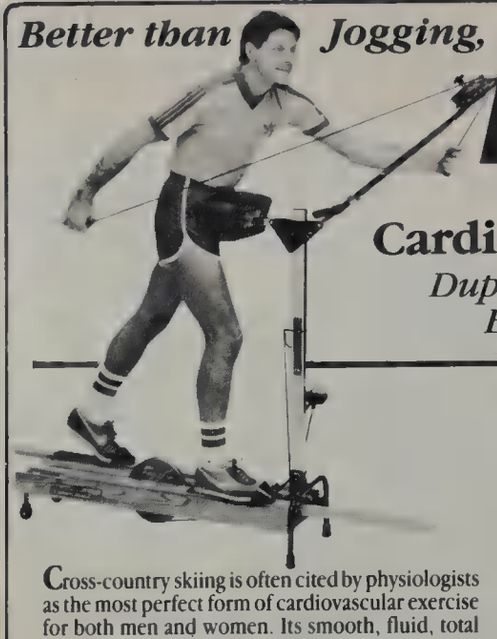

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Mr. Zaloom anticipates that the g
in the San Joaquin and Sacramento
leys will harvest 40 to 50 million pou
nuts this year. He remembers the
when America grew only 1.5 m
pounds, and he is not timid about pr
ing that when the trees planted in Ca
nia in the 1970s come into full matur
the 1990s, the domestic crop will su
100 million pounds.

The California pistachio boom
major push when the Internal Rev
Service allowed Americans to inve
tax-sheltered pistachio orchards. Bui
on this "seed money," growers applie
vanced plant science and mechanica
vesting to their new trees. In Californ
vera is typically grafted onto hardier
stocks from other members of the
chio genus. Systematic pruning and
tegic placement of the pollinating
"Peters" variety (one for each eight
female "Kermans") have helped esta
flourishing, efficient groves.

Conventional soft-fruit type harve
equipment collects nuts from two tre
minute, shaking the nuts loose, cle
them, removing leaves and twigs.
men can harvest an acre in an hour

But the most dramatic improve
mechanization brought to pistachio
essing is the ability to dry and hull th
within twenty-four hours of colle
which greatly reduces mottling o
shells. Most nuts are now hulled b
friction of rubberized belts running
lel to each other and at different sp
This pinching conveyor spews the h
nuts into a water bath that washes
Empty nuts float; filled ones sink an
sent on to a forced-air drier for a ten
treatment. An electric eye then sor
any blemished nuts.

California pistachios are not only
tier than Iranian ones; they are also
ger. Iranians range from eighteen to
nuts per ounce. Californians run as
fourteen to the ounce. And many mo
split Iranian nuts reach market.

But do the Californian nuts tas
good?

"Considerable controversy exists
United States concerning the re
merits of home-grown, as opposed
ported, pistachios," writes Fre
Rosengarten, Jr., in *The Book of E*
Nuts. "The American importers o
nian and Turkish pistachios describ
California counterparts as beautifu
tasteless. The California producers,
other hand, claim their pistachios
about the same as the imported nu
are larger, fresher, and easier to ope

Mr. Rosengarten, an associate in
nomic botany at Harvard's Botanica

rom whose new book much of the pistachios in this article derive, t take a stand on this dispute. Mr. says he is buying far fewer Ira-ts than ever before. "The Ameri-nsumer prefers the California ne says. "The California pistachio ttractive nut, and the consumer is t discriminating about subtle dis-s in taste. The California nut does seem drier. The drying process is than sun drying. But it's a very difference."

e for myself, I bought two differ-nds of California pistachios, la-s such, in a supermarket. Unable to ranian pistachios at any Manhat-rmet food shop, I went to Atlantic in Brooklyn, the national center ect food imports from the Near t Sahadi's market, I obtained two f Iranian nuts, one unlabeled, the as Zenobia's Shah variety.

our kinds of nuts I tasted were un-ed and undyed. There were virtu-ally no unsplit nuts in the two vacuum-packed jars from California. There were a small but noticeable number of unsplit nuts from Iran. The Californias were slightly larger.

As to taste, the Zenobia Shahs stood out. They were faintly aromatic, more complex. The other three were all perfectly good nuts, however, and I ate them all, leaving a large pile of tan shells on my desk.

This was a highly informal test, of course, and it did not include Albert Zaloom's favorite kind of pistachio, the tough little nuts grown in Sicily and rarely exported. But I emerged from my pistachio feast feeling largely content with the first fruits of the California boom, glad that the price of pistachios is dropping rapidly, and completely unsated in my appetite for this delectable drupe.

Raymond Sokolov is a writer whose special interest is the history and preparation of food.

rrot Pudding with Cardamom and Pistachios (Gajar ki Kheer)

(adapted from *Classic Indian Cooking*, by Julie Sahni)

ups milk
ablespoons long-grain rice
ups firmly packed peeled and rated carrots (about 1 pound)
up sugar
ablespoons slivered blanched al-nonds
easpoon ground cardamom
easpoon rose water
up heavy cream
ablespoons chopped, blanched, un-alted pistachios

ing the milk to a boil in a heavy-bot-ned 3-quart pan. Add the rice and r for a few minutes to prevent its set-ng. Reduce heat to medium–low, d cook the milk at a bubbling boil for minutes. The rice will be thor-ghly cooked and the milk reduced half. Stir often to insure that no skin ms.

ld carrots and continue cooking, un-vered, for 15 minutes or until the rrots are cooked and most of the lk has been absorbed by the carrots. ir often to prevent burning. (The ntents of the pan should reduce to a ck, pulpy sauce.)

ld sugar and almonds and cook, stir-g constantly, until the pudding is ry thick and begins to stick to the ttom of the pan (about 10 minutes). rn off heat, and let the pudding cool room temperature.

ir in cardamom, rose water, and cream. Cover with plastic wrap and chill thoroughly. Check the consistency of the pudding before serving. It should be slightly thinner than American rice pudding, but not runny. If it looks very thick, add a little milk. Serve in individual dessert dishes, sprinkled with chopped pistachios.

Yield: Six to eight servings

Pistachio and Honey Candy, Peloponnese Style (Pasteli Me Fistikia)

(adapted from *The Food of Greece*, by Vilma Liacouras Chantiles)

1 pound fresh, unsalted pistachio nuts
1¼ cups sugar
1 cup honey
Butter or oil

1. Preheat oven to 250 degrees.
2. Peel and place pistachios on a baking sheet, then roast in the oven for 20 minutes. Remove from the oven and cut into quarters.
3. Meanwhile combine the sugar and honey with 1½ cups water in a heavy pan and stir over medium heat until dissolved. Lower the heat and boil to the very firm ball stage (250 to 256 degrees), toss in the pistachios, and stir. Then remove from the heat.
4. Butter or oil a marble slab, jelly roll pan, or any aluminum baking pan and quickly spread the candy over it, using a spatula or knife.
5. Allow to cool. Then cut into squares and store in covered containers.

Yield: Fifty one-inch squares

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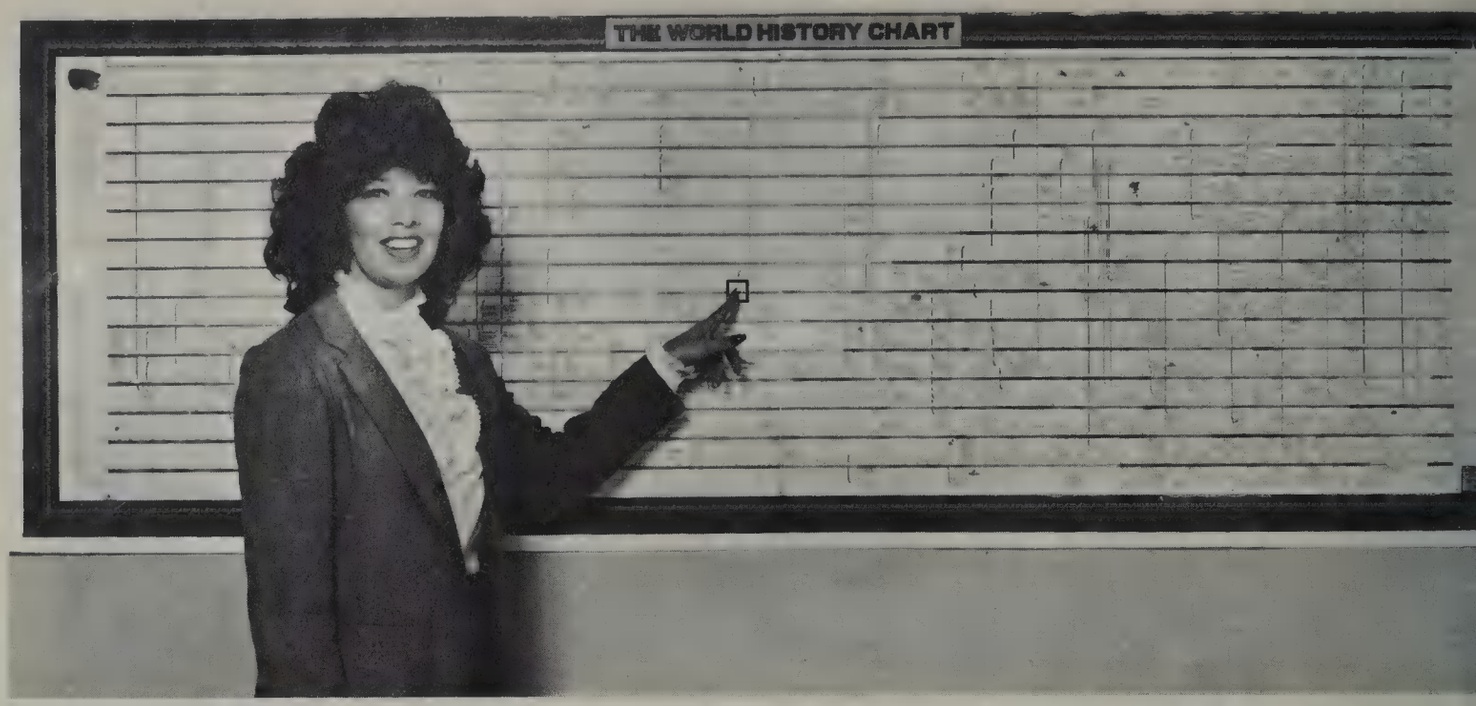

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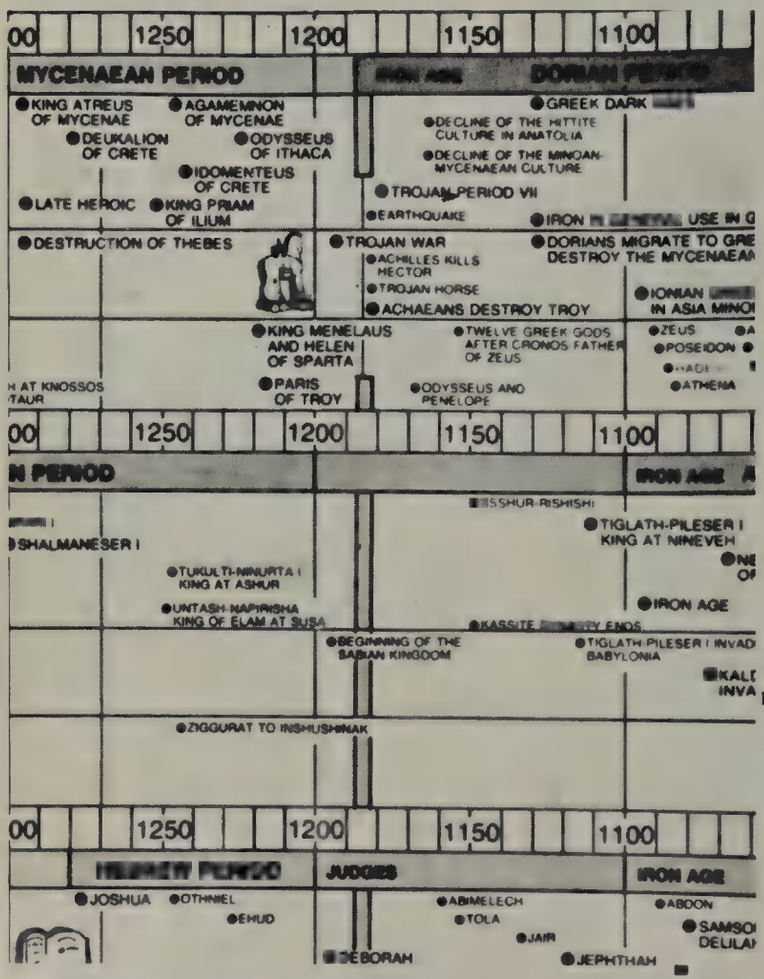

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The Long Goodbye

thia D'Vincent and her husband, Russ Nilson, saw this ack whale breaching near the tip of Admiralty Island in two summers ago. Cynthia, who reports that the whale to breach after a long feeding session with seven other wasn't sure what sent it skyward. "It could have been at, but we had been watching them all day," she says. "I t maybe it was trying to help itself digest its food."

do whales breach? To answer that question, *Natural* organized a symposium on breaching behavior in humphales and, to save everyone a lot of time and airfare, we no one. Instead, we talked to researchers from disparate f the United States and present here an edited transcript t was said.

.: Hello. Why do humpback whales hurl themselves headt of the water, then crash down to the surface?

VARD WINN (University of Rhode Island): Nobody really why they breach. A long time ago people thought they ying to get rid of parasites such as whale lice.

ER TYACK (Woods Hole Oceanographic Institute): Well, o lose a large mass of skin when they breach.

N: They may be responding to excitement or it may serve ggressive display, to drive another whale out of a territory.

.: You mean on the breeding ground?

N: That would be one instance. They also breach when is rough.

DALE RICE (National Marine Mammal Laboratory, Seattle): I think the excitement idea corresponds to what I've seen. They breach on the breeding grounds and on the feeding grounds in summer, and it looks to me like they're just having fun. Sometimes they slap a flipper down and you can hear it a mile away.

C. SCOTT BAKER (University of Hawaii): I've seen three basic types of situations in which breaching occurs. Calves breach all the time and this is probably just play, like frolicking in lots of mammals. When whales are under stress of any kind or are disturbed by humans—say by research boats—they'll breach more often. Finally, I've seen it in social encounters. When whales affiliate or disaffiliate, you may see breaching. Don't forget, though, that while a breach is spectacular to us, it's probably lost on every other whale in the vicinity. The main thing is the noise. Sometimes it may be a warning noise that says, "This is how big and excited I am."

TYACK: But they do have better ways of producing sound. Their song, for example, is acoustically higher than the noise of a breach. But the breach may be a more dramatic sound.

N.H.: Mr. Baker, could you elaborate on your reference to affiliation and disaffiliation?

BAKER: Well, sometimes when pods of whales come together, you'll see a few breach as they're coming together. Or if two whales are splitting up, they may both breach as they swim off.

N.H.: Both of them? You mean as if they're saying goodbye?

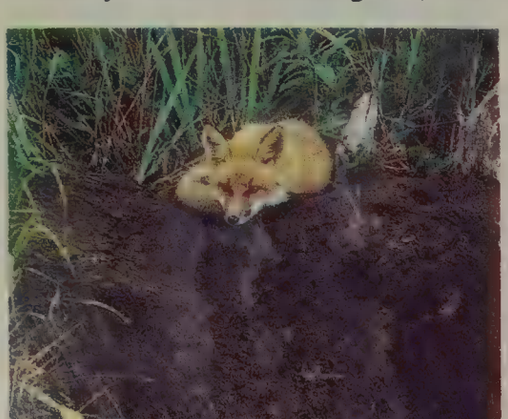
BAKER: Well, something like that.—*D.W.* ▶

Photographs by Cynthia D'Vincent

Additional Reading

Bald Ibis (p. 38)

Endangered Birds, edited by S. Temple (Madison: University of Wisconsin Press, 1978), is a collection of articles from the Symposium on Managing Techniques for Preserving Endangered Birds. It reviews the current methods used to save bird species in trouble, some of which go far beyond the old techniques for helping wildlife (such as legal protection and habitat preservation) to specific and intensive intervention into a species' life history and ecology. For example, to prevent the extinction of a small population of waldrapps (bald ibises' closest relatives) in Turkey, ornithologist U. Hirsch took some unusual steps, using highly untraditional methods. He widened the birds' breeding ledges and built additional ones; he prevented rubbish from being thrown from above and protected the site from other human disturbances; he identified the birds' preferred feeding areas and studied the effects of insecticides; and he tried to revive the local people's traditional ibis celebrations to engender concern for the birds' welfare. The bald ibis is now considered endangered by many ornithologists. G. Archibald et al. discuss the bird's status and its chances of survival in "Endangered Ibises (Threskiornithidae): Their Future in the Wild and in Captivity," which appeared in the *1980 International Zoo Yearbook* (pp. 6–17), an annual publication of the Zoological Society of London. W.R. Siegfried's "The Status of the Bald Ibis of Southern Africa" (*Biological Conservation*, vol. 3, pp. 88–91, published by Elsevier Publishing Co., New York) summarizes the bird's population, distribution, and other general data. Published in 1971, it is now slightly out of date but still valid as a good starting point for those interested in the ibis. To understand the bald ibis of the Drakensberg escarpment and the timing of its breeding system, it is useful to know about the area's fire ecology. A recent book, *Ecological Effects of Fire in South African Ecosystems*, edited by P. de V. Booysen and N.M. Tainton (New York: Springer-Verlag, 1984), takes a wide-ranging look at this field, exploring grass-burning management techniques and other related topics.



R. McNeil; Bruce Coleman Inc.

Red Fox (p. 46)

According to J.D. Henry, the red fox has evolved to become a very catlike canid, particularly in the ways it hunts. Henry, who studied red foxes in northern Saskatchewan, discusses their predatory strategies and proposes a theory of convergent evolution between foxes and cats in his last article for *Natural History*, "Fox Hunting" (November 1980, pp.60–69). Henry is also working on a new book—due out from the Smithsonian Institution Press, Washington D.C., sometime this year—in which he expands on these ideas. Two other books devoted to this species in particular are H.G. Lloyd's *The Red Fox* (London: Batsford Limited, 1980, distributed in the U.S. by David and Charles, New York), which concentrates on foxes in Britain, and *The Red Fox: Symposium on Behaviour and Ecology* (The Hague: Junk, 1980, distributed in the U.S. by Kluwer Boston, Higham, MA), a collection of articles edited by E. Zimen. A more general work is *The Wild Canids: Their Systematics, Behavioral Ecology, and Evolution,* edited by M.W. Fox (New York: Van Nostrand Reinhold, 1975). This thorough review of canid biology includes studies of the red fox's behavior and ecology, its status in the United States, and its genetics and physiology. D.W. Macdonald has written a number of articles on red foxes, among them "Helpers in Fox Society" (*Nature,* vol. 282, pp. 69–71), which takes a look at these animals' social organization and ways of rearing their young. Macdonald is also the author of *Vulpina* (London: Collins, 197 charming children's book on red f that is both amusing and scientificall curate. M. Taketazu's *Fox Family* (York: John Weatherhill, Inc., 19 translated from the Japanese and ada for Western readers by R.L. Gag highly recommended for its excepti collection of photographs recording a in the life of the foxes of Hokkaido pan's northernmost island. Coyotes also members of the canid family and ilar to foxes in many ways; for compar see *Coyotes*, edited by M. Bekoff (York: Academic Press, 1978), whic cludes articles on biology, behavior, management. Bekoff and M.C. Well plore the coyote's behavioral adapta to different food supplies and its proaches to predation in "The Social I ogy of Coyotes" (*Scientific Amer* April 1980, pp. 130–48). P.D. Moehl looks at the altruistic behavior of anc of the fox's close relatives in "Ja Helper and Pup Survival" (*Nature,* 277, pp. 382–83).

Genetics and Trees (p. 58)

If you are interested in learning m about this topic, you will probably ha resort to technical journals, where m of the pertinent material is found. An the most directly related articles are " netic Differentiation among Gro Forms of Engelmann Spruce and Su pine Fir at Tree Line," by M.C. Grant J.B. Mitton (*Arctic and Alpine Resea* vol. 9, pp. 259–63); "Genetic Variati Space and Time in a Population of derosa Pine," by Y.B. Linhart et al *redity,* vol. 46, pp. 407–26); "Relation Between Heterozygosity for Enzyme and Variation of Morphological Cha ters in Natural Populations," by Mitton (*Nature,* vol. 273, pp. 661– and "Observations on the Ecology Evolution of Quaking Aspen, *Pop tremuloides* in the Colorado F Range," by Mitton and Grant (*Amer Journal of Botany,* vol. 67, pp. 1040– Easier to understand, although per not as closely connected to this issue's cle on trees and genetics, are *Land A the Trees*, by H. Zwinger and B. Wi

ork: Harper and Row, 1972), a
eneral-interest book on American
undra, and *From Grassland to*
by C. Fleischer Mutel and J.C.
(Boulder: Johnson Publishing
34), a recent book on the natural
of Colorado. Some of the photo-
in this article also appear in J.
Colorado: Magnificent Wilder-
oulder: Johnson Publishing Co.,

halers (p. 66)
Chase, by D. Francis (New-
nd: Breakwater Books Ltd., 1984),
e history of whaling in the Cana-
ctic, is available as an inexpensive
ck, but it doesn't contain much in-
on about Inuit whalers. One book
s this gap is W. Gillies Ross's
and Eskimos, an exploration of
Bay from 1860 to 1915, published
and available from the National
ns of Canada, Marketing Ser-
ttawa K1A OM8, Canada. Gillies
o edited *An Arctic Whaling Diary*
: University of Toronto Press,
he journal kept by Capt. George
during his 1903–05 visit to Hudson
Calabretta writes about the whal-
tain in "Captain George Comer
Arctic," an article in the journal of
stic Seaport Museum (*The Log of*
Seaport, Winter 1984, pp. 118–
uarterly that comes with member-
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ions department, in Mystic, CT
or a single copy. The museum also
ed, in 1969, one of the earliest
n this subject, R.A. Stackpole's
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hich is short but chock-full of in-
on. For a discussion of Inuit cos-
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Authors

"I have been an avid birdwatcher since I was twelve and have particularly admired ibises for their graceful, curvaceous forms," writes **David E. Manry** (p. 38). In pursuit of his prime interest, Manry spent one summer doing research on the nesting habits of the American white ibis in east Texas and five years as an avian researcher in South Africa for the Percy FitzPatrick Institute of African Ornithology. Now a graduate student in environmental, populational, and organismic biology at the University of Colorado, he plans to investigate the reproductive biology and mating systems of three closely related species of ibises on the plains of Venezuela for his Ph.D. dissertation. "I'm especially interested in pair formation, duration of pair bonds, remating, intraspecific nest parasitism, promiscuity, and maternity/paternity exclusion studies," he says. Manry's research allows him to indulge in some of his favorite hobbies—hiking, photography, and travel.

In 1971, **J. David Henry** (p. 46) was in Prince Albert National Park, Saskatchewan, working on a black bear management project, but he kept getting distracted. Everywhere he turned he noticed red foxes, and the way they hunted and interacted with each other intrigued him. Henry found that if he was patient, he could watch these animals and piece together what their daily lives were like in the wild. In o words, he was hooked. And for the fourteen years, he has been feeding habit—conducting red fox stu mainly in northern Saskatche where he lives, but also as far nort the Arctic islands. Henry teaches at University of Regina and is presider the National and Provincial Parks A ciation in Canada.

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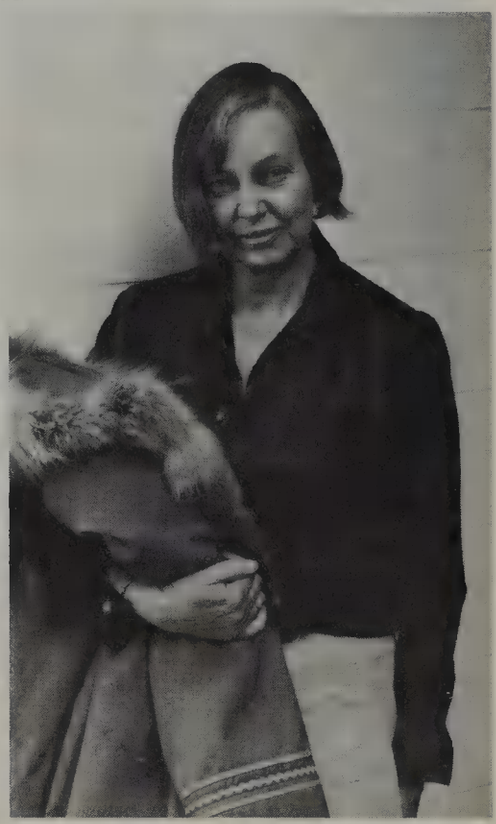
Authors

Jeffry B. Mitton (p. 58) is beguiled by how organisms in natural populations differ genetically and how the differences affect their physiology, life span, and fecundity. He has examined genetic variety in many plants and animals that inhabit a wide range of environments. His attraction to this subject, however, did not begin with the spruces, firs, and pines, which he writes about in this issue of *Natural History*, but with three marine organisms: the blue mussel, the common killifish, and the American eel. Research on these animals took him from Florida to Nova Scotia, but that was just the beginning. After earning his doctorate in 1973 from the State University of New York at Stony Brook, Mitton spent a year as an NIH postdoctoral fellow at the University of California, Davis, studying ryegrass. In addition to trees, he does fieldwork on the tiger salamander in Colorado and the queen conch in the Caribbean. An associate professor of biology at the University of Colorado and secretary of the Society for the Study of Evolution, Mitton's favorite sport, understandably, is scuba diving.



"I became interested in gath
whaling stories from Eskimo p
while interviewing the Eskimo arti
Cape Dorset on Baffin Island," ex
Dorothy Harley Eber (p. 66). "Sinc
1950s, the Eskimo have made
mark as graphic artists and scul
and while learning about the old w
life that they express in their art,
learned that whaling was an impo
part of their past experience." E
journalist with a special regard for
mentary reportage and the match
photographs with oral history, has
some fifteen field trips to various pa
the Canadian Arctic. She is cur
finishing a manuscript built arou
terviews with people who knew th
kimo whalers—some of her infor
sailed as children on whaling vessel
their whaler fathers. Eber's researc
done for the Urgent Ethnology
gramme, Museum of Man, Ottawa
on grants from the Canada Counc

Cynthia D'Vincent (p. 97) and her husband, Russ Nilson, run a research vessel—a quiet, sturdy, 93-foot brigantine called *Varua*—out of Monterey, California. Marine mammalogists often use some of their money to rent *Varua* and its family crew for whale research in the Pacific. "I could've gone the Ph.D. route, that whole thing," says D'Vincent. "I just wasn't interested, and I'm still not, because it means a lot of the time you be out there." By "out there" she r the South Pacific or Hawaii or Alas anywhere else *Varua* points its When the boat is not engaged by o ers, D'Vincent and Nilson do thei research—which these days includ cording the song of humpback w Her photos in "The Natural Mor were taken with a 200-millimeter

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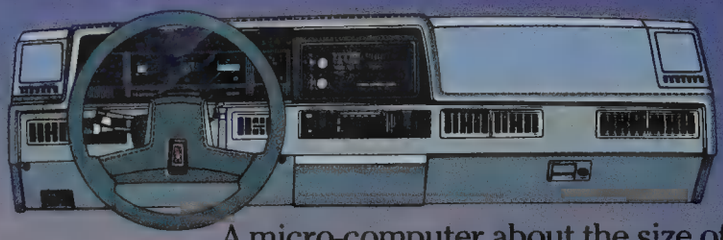

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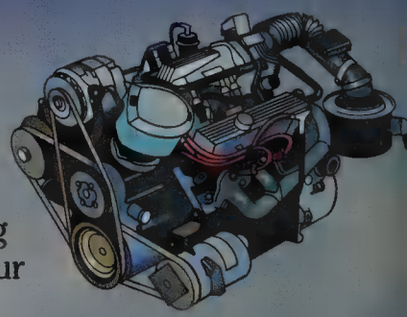

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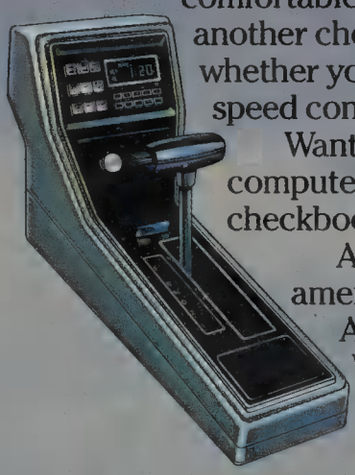

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HISTORY *(ISSN 0028-0712) is*
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0th Street, New York, N.Y. 10024.
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The End of the Lines

Mass extinctions could change the course of evolution before the baby boom generation grows old

by Norman Myers

As many scientists and conservationists now know, we are on the verge of wave upon wave of extinctions. As is less commonly recognized, these extinctions may change the course of evolution. Human societies have long had an effect on the planet's biological systems, leading to the end of many species and occasionally to the formation of new ones. But unless we act superfast, this impending spasm of extinction will surely surpass all others in prehistory, in terms of the number of species involved and the speed with which it will happen. As in the past, new life forms will arise, but not at a fraction of the rate they are going to be lost in the coming decades and centuries. We are surely losing one or more species a day right now out of the five million (minimum figure) on Earth. By the time ecological equilibrium is restored, at least one-quarter of all species will probably have disappeared, possibly a third, and conceivably even more. With so many plants and animals gone, there will be a fundamental shift in evolution itself, as evolutionary processes go to work on a vastly reduced pool of species and as a few new species arise to fill in the gaps.

Of course, there have always been spasms of natural extinctions. The demise of the dinosaurs and their kin, together with numerous marine species, during the "great dying" 65 million years ago, eliminated between one-third and one-half of all animal and plant groups (although there were rather fewer species overall in those far-back times than today). There was an even greater megaextinction, during the late Permian 230 million years ago, when possibly three-quarters of all species were lost, out of a much smaller total than exists today.

But whereas the extinctions of the Permian, and of five other major episodes in the prehistoric past, appear to have extended over several million years at least, the current catastrophe has begun in the last few decades and is likely to do much of its damage by the middle of the coming century. Particularly since World War II, tropical forests, which cover only 7 percent of the earth's surface, have been under assault in Latin America, tropical Africa, and in Asia. These forests, which support about half of all species, are being cleared for agriculture and logged at an enormous rate. A third of them are already gone. Ecuador has lost half its forests, and in Madagascar, which has a quarter of a million species, two-thirds of which occur nowhere else, 90 percent of the forests have been cut. This is the case for country after country. Seventy percent of these losses have been brought about by peasants who practice slash-and-burn agriculture and have had to roam farther and farther into the forests to grow subsistence crops. Another 15 percent of the loss is due to cattle ranching in Latin America—the so-called hamburger connection in which large fast-food outlets in the United States and Europe foster the clearance of forests to produce cheap beef. And 15 percent of the forests have been cut for lumber. If this pattern continues, it could mean the demise of two million species by the middle of the next century.

Two other crucial ecosystems that have suffered terribly in recent decades are wetlands and coral reefs. Coral reefs, for example, cover about 220,000 square miles of the ocean floor in the Indian Ocean and the western Pacific, among other areas, and support about 200,000 species. During the past fifty years, countries such as the Philippines, Kenya, and Tanzania have dredged reefs in the
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make shipping lanes. Coral reefs ar
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off many more species than other en
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Not only is the current catast
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will also undoubtedly affect mor
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the University of Chicago, the avera
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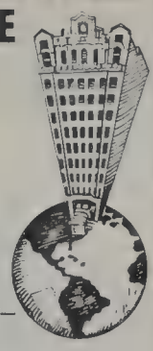

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will be the hiatus in evolutionary processes that they will cause. And we are being optimistic when we call it a hiatus. A more likely outcome is that many evolutionary developments that have taken place since the first flickerings of life will be suspended or even terminated.

The forces of natural selection can work only with the resource base they have. If that base is drastically reduced, the result could be a disruption that could persist far into the future. So far as we can discern from the geologic record, the "bounce-back" time may require several million years. Following the crash during the late Permian, for example, when the marine invertebrates lost about half their families, it took 20 million years before the survivors could establish even half as many families as they had lost.

In short, as M.E. Soule and Bruce A. Wilcox have written, "Death is one thing; an end to birth is something else."

Even as this megaextinction episode is taking place, some of the same disruptive processes causing it could lead to an outburst of speciation—the formation of new species. We can consider several categories of disruption. When species' populations are cut off from one another, which occurs when humans destroy swathes of habitat through the middle of a species' range, each population develops in its own way. Such a population eventually becomes distinct enough from the others that it can no longer interbreed with them, whereupon it ranks as a new species.

We can discern the results of this when we consider the great lakes of East Africa. In Lake Tanganyika there are 134 cichlid fish species that are endemic, that is, found nowhere else, while in neighboring Lake Malawi there are about 200 such species. Although the two lakes are no more than 200 miles apart (they were once one big lake), they possess not a single cichlid in common. At some point in the past, an ancestral species living as a single population began to split up into smaller populations, probably because of small changes in the shoreline that cut some fish off from others. Over the course of millions of years, the microhabitats of each of these populations led to the formation of hundreds of new species. In a small "offshoot" of Lake Victoria, known as Lake Nabugabo, which only 4,000 years ago was separated from its parent lake by a sandstrip that is now less than two miles wide, there are six species of *Haplochromis*, five of them endemic. These have to rank among the "youngest" fish species known. Under natural conditions, then, fish can radiate, or throw off new species, in relatively short periods.

A second sort of disruption th
greatly accelerate natural evolu
processes is the introduction of
sources or other materials into a
environment. In Hawaii, for ex
there were no bananas until human
duced them about 1,000 years ag
which several moth species of the
Hydylepta emerged. The interestin
about these new moths is that th
exclusively on banana plants; oth
cies of the genus feed on grasses,
lilies, palms, and legumes.

In just the past few decades mo
display industrial melanism have e
in Britain; now we have mos
among other insects, that are imm
DDT and other pesticides, plus
that grow on the tailings of lead a
per mines. None of these are new
as yet, but they are headed in tha
tion. Where human exploitation of
environments leads to fragmenta
wildlife habitats, the process of ada
and change speeds up massively.

The disturbance of natural e
ments also tends to open up new ni
ecological living spaces. This allow
species to expand and then to dive
North America, for example, the
of agriculture and the proliferatio
ban refuse created a rapidly exp
niche that remained vacant until t
lish sparrow (sometimes known
house sparrow) arrived in the 185
sparrow exploited the man-made o
nities it found and quickly coloni
entire continent. From this sort of
which scientists call adaptive ra
new bird species can emerge in re
short order. The sparrow has b
North America little more than a h
years, but already it has develope
distinctive races, even subspecies.

The coyote appears to be anothe
ple. Because the wolf and other c
tive carnivores have been widely
nated, and because growing li
herds offer much prey, the coyote
tended its range during the prese
tury until it now lives in every sta
consequence, the eastern coyote, v
about one-quarter larger than the
coyote and perhaps has some gen
the Algonquin wolf, now deserves
as a subspecies.

All of these are examples of th
ative" effects stemming from hun
ruption of the environment. B
marked acceleration of speciation
remotely match the amount of ext
Whereas extinction can occur in ju
decades, and sometimes in just a
two (a valley in a tropical forest
pocket of endemic invertebrates

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David Attenborough in The Living Planet: A Portrait of the Earth

A spaceman landing on Planet Earth would discover that various parts of this uniquely rich world, even though they are widely separated in space are, nonetheless, remarkably similar. The Sahara in the northern half of Africa, the southern part of North America and the centre of Australia are very like one another—bakingly hot and starved of water. They are deserts. And, amazingly, although the animals and plants that live in these deserts come from different ancestral stocks, they nonetheless resemble one another to a surprising degree, moulded by similar conditions to develop similar techniques for solving similar problems of survival.

If that spaceman then travelled round the equator from South America to Borneo to West Africa, he would find, once again, extraordinary similarities—lush forests nearly two hundred feet high, swarming with more animals and plants than you could find in any other kind of country, different in details yet again and again paralleling one another.

This series follows the travels of such a spaceman. One by one, we visit the great environmental regions of the world to examine the ways in which animals and plants, over the millennia, have managed to colonise not only the most fertile and favoured parts of Planet Earth, but even the most hostile. By the time we have finished our tour, we will have scanned the entire globe from the Poles to the equator, from the depths of the ocean to the outer limits of the atmosphere. By discovering the ways in which living organisms have colonised these varying environments, we will begin to understand how they continue to exist. And by doing that we will be able to see more clearly not only what has to be done if we want to conserve them—but what marvels we will lose if we fail to do so.

David

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converted into pastureland within a single season), the time required to produce a new species is much longer. It takes decades for outstandingly capable contenders such as certain insects; centuries, if not millennia, for many other invertebrates; and hundreds of thousands or even millions of years for most mammals.

The most important factor in encouraging speciation is that a broad-scale extinction of species will vacate many niches. This will allow new species to emerge more rapidly than when there are diverse and abundant numbers of species, as there are today. But we know too little about this process in principle, and it will take too long to reveal itself in practice, for us to make any prognostications right now.

What we can suppose with some confidence is that the reduced stock of species that survives the present burst of extinction will likely contain a disproportionate number of opportunistic, or "clever," species. Such species rapidly exploit newly vacant niches (by making widespread use of food resources), are usually short-lived (with brief gaps between generations), feature high rates of population increase, and are adaptable to a wide range of environments—all traits that enable them to exploit new environments and to make excellent use of "boom seasons." These are the attributes that enable opportunistic species to prosper in a human-disrupted world, where they often become pest amples include the English sparrow European starling, the housefly, the bit, and the rat, plus many "weed" p

But this trend toward opportunism ries with it a sizable cost. The sparro example, is adept at usurping the stocks and nesting sites of many n North American birds, notably bluel wrens, and swallows. Entire populati these species are being displaced and planted, leaving them with less prom prospects of survival. The same thi happening in other regions of the that the sparrow has colonized with help, especially South America, Sout rica, southeastern Australia, and Zealand.

A parallel situation has arisen in n western Europe. The herring gull's p lations in the North Atlantic are thirty times larger than at the beginni the century, mainly because of the ing amounts of domestic garbage, sew and fishing offal. As a result, several birds, notably the rarer terns, are suff through competition for nesting spa Britain, there are now only about 2,0 seate terns left, or one-quarter as ma in the mid-1960s. Both the sparrow the gull illustrate how the rise of o tunistic species can contribute furth the extinction pattern.

If generalist, or opportunistic, sp will profit from the coming crash, the cialists, notably predators and para will probably suffer disproportion high losses. This is because their life s are much more refined than the oppo ists'; and their numbers are gene much smaller anyway. Since the sp ists are often the creatures that keep the populations of opportunists, there be little to hold the pests in check. T probably less than 5 percent of all i species deserve to be called pests. E extinction patterns tend to favor c species, the upshot could soon be a s tion where these species increase their natural enemies can no longer trol them. In short, our descendants find themselves living in a world w "pest and weed" ecology.

Some observers may assert that ou works of parks and other protected will surely keep species alive, albeit remnant stocks of individuals. But the next several thousand years, eve best-protected areas will slowly lose of their species, as habitat destructi creasingly isolates them. Several r studies of species' distributions in p and other islands of wildlife provi with some insight into this process. established, a park is virtually certa

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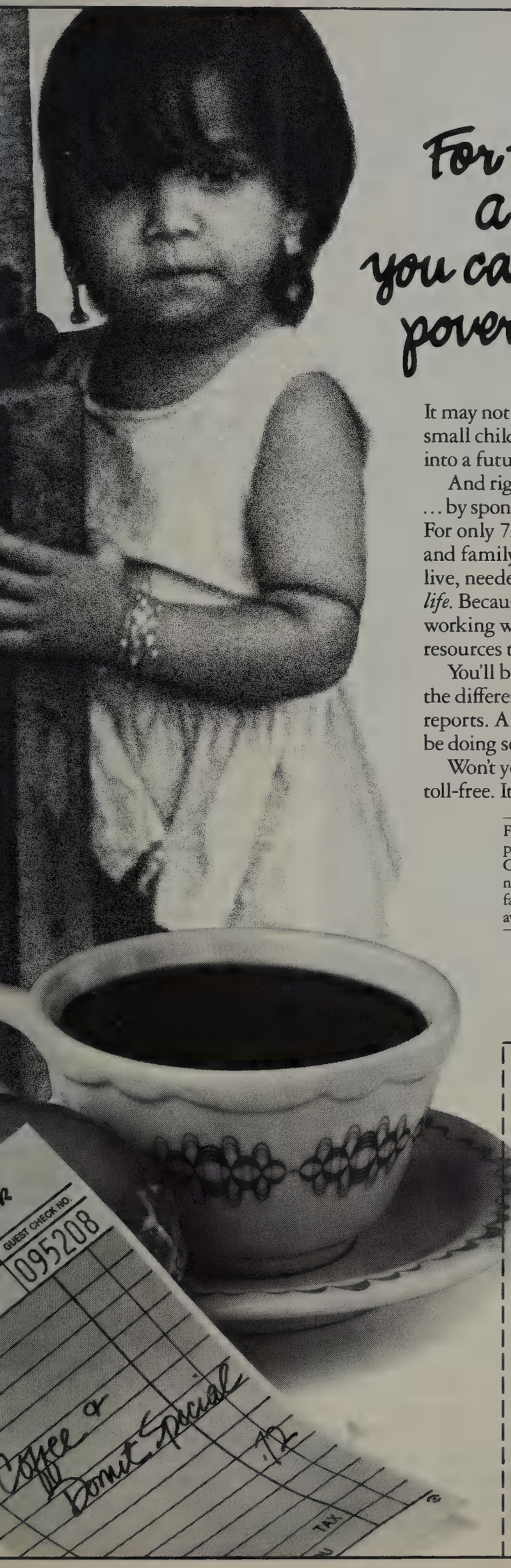

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become an island of intact nature in a sea of human-dominated, and hence alien, environments; and the species on that island will steadily decline in number, compared with what was living there when the area was part of a "continent": an island can support only so much life. Generally speaking, if 90 percent of an original habitat is grossly disrupted, and the remaining 10 percent is protected, we can expect to save no more than about half the species in that area.

This means that, in operational terms, a tropical park of, say, 4,000 square miles (larger than Yellowstone National Park, the largest park in the conterminous United States) could well lose about half of its large mammal species in a few thousand years—unless park managers master "constructive interference," that is, management to safeguard depleted gene pools (a challenge we are barely coming to grips with). It further means that if all that eventually remains of the tropical forests of, say, Amazonia amounts to the areas currently protected, we can expect, according to Daniel Simberloff of Florida State University, to lose roughly two-thirds of the region's half million (minimum figure) species within a few thousand years.

For sure, a few thousand years is a long time by some standards. But in the conservation perspective, it is the twinkling of an evolutionary eye. The spectacular throngs of East African savannas—the vast herds of elephants, giraffes, zebras, and antelopes, together with their lions and other predators—probably face the same deadline. Because we have established so few parks of suitable size, and because our options for establishing any new parks are rapidly running out, certain observers, such as Soule and Wilcox, believe that we could well lose many, if not most, of our large mammals and birds within another 5,000 years—"large" meaning anything heavier than a few pounds. If we use the crash at the end of the Cretaceous as a model, we can anticipate that the eventual mammal survivors of the imminent crisis will likely be small-sized creatures, such as bats, rodents, rabbits, small canids, weasels, and raccoons.

More important, a park-based strategy for protecting species would not help much in safeguarding the future course of evolution. Of course, were we to establish extensive networks of outsized parks, we could keep many more species alive. But this would certainly not assure the perpetuation of evolutionary processes as they operate today. Even fairly small mammals apparently need unexpectedly large areas if they are to retain their capacity to throw off new species. To
optimistically, we are probably for
ing the prospect that our decendant
ever see a distinctive variation of the
or the cheetah or any other large cat,
which require huge ranges to mainta
size of populations on which natural
tion can work.

All this raises questions virtual
large as conservationists can visu
Would we be content to hold on t
present pool of species, vast as that
would be? Or should we not pay equ
tention to the future of evolution? I
Franklin of the Genetics Resources
oratory near Sydney, Australia, fr
the issue this way: Do we wish to pre
precise phenotypes of particular sp
that is, maintain the status quo, or
wish to maintain phylogenetic lines
will permit evolutionary adaptatio
persist, thereby leading to new speci
it sufficient for us to keep, for exa
just the two elephant species we al
have, or should we also try to hold ope
option of further elephantlike spec
the distant future?

These are enormous questions,
enormous implications for conserv
strategy. Elephants, along with most
mammals, are inclined to move aro
good deal, which enables them to
tain gene flows across large territori
a result, their gene pools are fairly un
in scope. In this respect, an elepha
East Africa may not be so different
one 2,000 miles away in South A
Some biologists would assert that t
maining stocks of elephants, extensi
they are, may well be the minimu
keep open the possibility of speciati

Furthermore, elephants have very
breeding rates (one calf every fourth
at best). Many insects, by contrast,
immense breeding capacities and
turnover rates, offering them quick a
ability to ecological changes. Ge
changes get passed along quickly.
leaves them well suited to survive the
ronmental upheavals of human acti
in the decades ahead. Elephants, w
and other mammals that repro
slowly, with a comparatively tiny cap
for genetic adaptation, will be at ext
evolutionary disadvantage. All the
they should get special attention fro

These, then, are some of the issu
Homo sapiens to bear in mind as we
to impose a fundamental shift on e
tion's course. The biggest dilemma
is that as we proceed on our disru
way, we give scarcely a moment's th
to what we are doing. If we thought
it a bit more, would this truly be wh
want?

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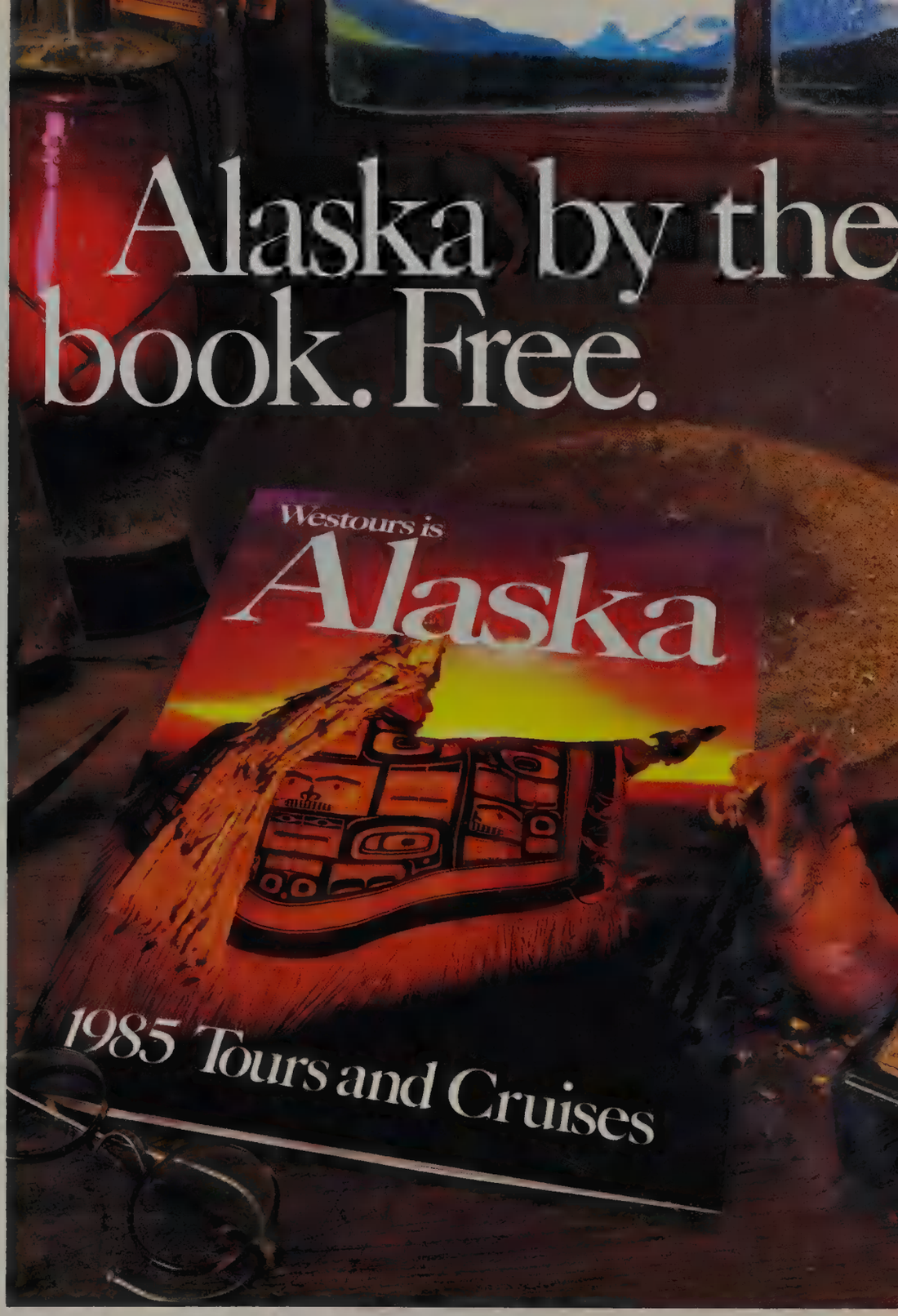

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Unfortunately we are "deciding" out even the most superficial reflect deciding all too unwittingly, yet tively and increasingly. The impe upheaval in evolution's course coul as one of the greatest biological r tions of paleontological time. It will in scale and significance the develo of aerobic respiration, the emerge flowering plants, and the arrival of li animals. But of course, the prosp degradation of many evolutionary c ties will be an impoverishing, not ative, phenomenon.

In short, the future of evolution s rank as one of the most challenging lems that humankind has ever en tered. After all, we are the first s ever to be able to look upon nature's and to decide whether we would re part of it—to consciously determin lution by what we do or don't do.

Fortunately there are signs—a glimmerings—of a new spirit eme The mass extinction of species is no seen as a preoccupation of cutesy-cr enthusiasts and ecofreaks. It is bein ceived as a vast rending of the fabric with pragmatic implications for ci around the world, now and for gener to come. In turn, the message is picked up by political leaders—mos by the government of the United S In 1981, the State Department con an international Strategy Conferen Biological Diversity (meaning biol depletion). And in 1983 Congress p the International Environment Prot Act, which requires the govern through its foreign aid programs, a other activities, to take special acco species communities and gene rese throughout the world.

By comparison with the needs situation, this can all be viewed as f little and far too late. But it is a st ward recognizing one of the great s issues of our time. The first great wa extinctions are only beginning to over the earth. We can still save spec the millions. Should we not conside selves fortunate that we alone amon erations are being given the chance t port the right to life of a large share fellow species and to safeguard th ative capacities of evolution itself?

Norman Myers is a journalist a environmental consultant to such nizations as the World Bank, the In tional Union for the Conservation ture, and the World Wildlife Fun won the Fund's Gold Medal in 19 his conservation work. His latest bo GAIA: An Atlas of Planet Manage

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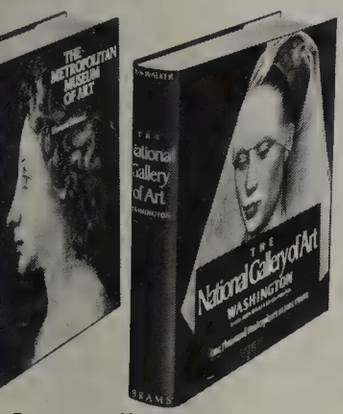

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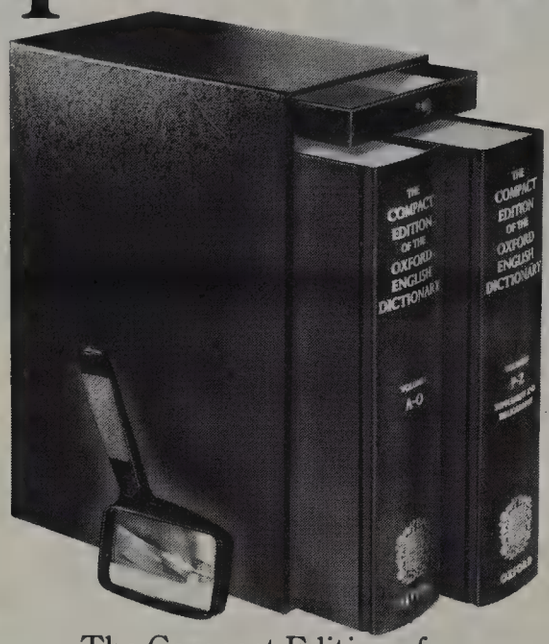

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Nasty Little Facts

In science, one fact, like a single foot soldier, almost never decides a great battle

by Stephen Jay Gould

As a devotee of Grade B detective films, from Charlie Chan (in all his incarnations) to the *Thin Man*, I have, perforce, spent an undue amount of time passively engaged in conversations about fingerprints. Since these discussions are interminable, one might suspect that they have also been eternal in the annals of criminology.

In fact, Scotland Yard officially introduced fingerprints as a tool for identifying criminals in 1901 (replacing the older Bertillon system, based on complex series of body measurements and the accompanying assumption, not always vindicated, that no two people will be alike in so many ways). The chief architect and promoter of the new system was Francis Galton, England's most eccentric scientific genius.

In his autobiography, Galton tells a story of Herbert Spencer's visit to his fingerprint lab. Galton took Spencer's prints and "spoke of the failure to discover the origin of these patterns, and how the fingers of unborn children had been dissected to ascertain their earliest stages." Spencer, quick to offer certain opinions about almost anything, told Galton that he had been working the wrong way round.

> Spencer remarked . . . that I ought to consider the purpose the ridges had to fulfil, and to work backwards. Here, he said, it was obvious that the delicate mouths of the sudorific glands required the protection given to them by the ridges on either side of them, and therefrom he elaborated a consistent and ingenious hypothesis at great length. I replied that his arguments were beautiful and deserved to be true, but it happened that the mouths of the ducts did not run in the valleys between the crests, but along the crests of the ridges themselves.

Galton then ends his anecdote by giving the original source for one of the top ten among scientific quotes. Spencer, dining with T.H. Huxley one night at the Athenaeum, stated that he had once written a tragedy. Huxley replied that he knew all about it. Spencer rebutted Huxley, arguing that he had never mentioned it to anyone. But Huxley insisted that he knew anyway and identified Spencer's debacle—"a beautiful theory, killed by a nasty, ugly little fact."

Some theories may be subject to such instant, brutal, and unambiguous rejection. I stated last month, for example, that no left-coiling periwinkle had ever been found among millions of snails examined. If I happen to find one during my walk on Nopsca beach tomorrow morning, a century of well-nurtured negative evidence will collapse in an instant.

This Huxleyan vision of clean refutation buttresses one of our worst stereotypes about science. We tend to view science as a truth-seeking machine, driven by two forces that winnow error: the new discovery and the crucial experiment—prime generators of those nasty, ugly little facts. Science does, of course, seek truth; it even succeeds reasonably often, so far as we can tell. But science, like all of life, is filled with rich and complex ambiguity. The path to truth is rarely straight, marked by a gate of entry that sorts applicants by such relatively simple criteria as age and height. (When I was a kid, you could get into Yankee Stadium for half price if your head didn't reach a line prominently drawn on the entrance gate about four and a half feet above the ground. You could scrunch down, but they checked. One nasty, ugly day, I started to pay full price, and that was that.)

Little facts rarely undo big theories all by themselves—the myth of David and Goliath notwithstanding. They can refute little, highly specific theories, like my conjecture about lefty periwinkles, but they rarely slay grand and comprehensive views of nature. No single, pristine fact taught us that the earth revolves around the sun or that evolution produced the similarities among organisms. Overarching theories are much bigger than single facts, just as the army of Grenada really didn't have much chance against the combined forces of the United States (though you'd think from the consequent appeals to patriotism that some gigantic and improbable victory had been won).

Instead, little facts are assimilated into large theories. They may reside there uncomfortably, bothering the honorable proponents. Large numbers of little facts may eventually combine with other social and intellectual forces to topple a grand theory. The history of ideas is a play of complex human passions interacting with an external reality only slightly less intricate. We debase the richness of both nature and our own minds if we view the great pageant of our intellectual history as a compendium of new information leading from primal superstition to final exactitude. We know that the sun is hub to our little corner of the universe, and that ties of genealogy connect all living things on our planet, because these theories assemble and explain so much otherwise disparate and unrelated information—not because Galileo trained his telescope on the moons of Jupiter or because Darwin took a ride on a Galápagos tortoise.

This essay tells the story of a pristine, unexpected little fact that should have mattered, but didn't particularly. It was

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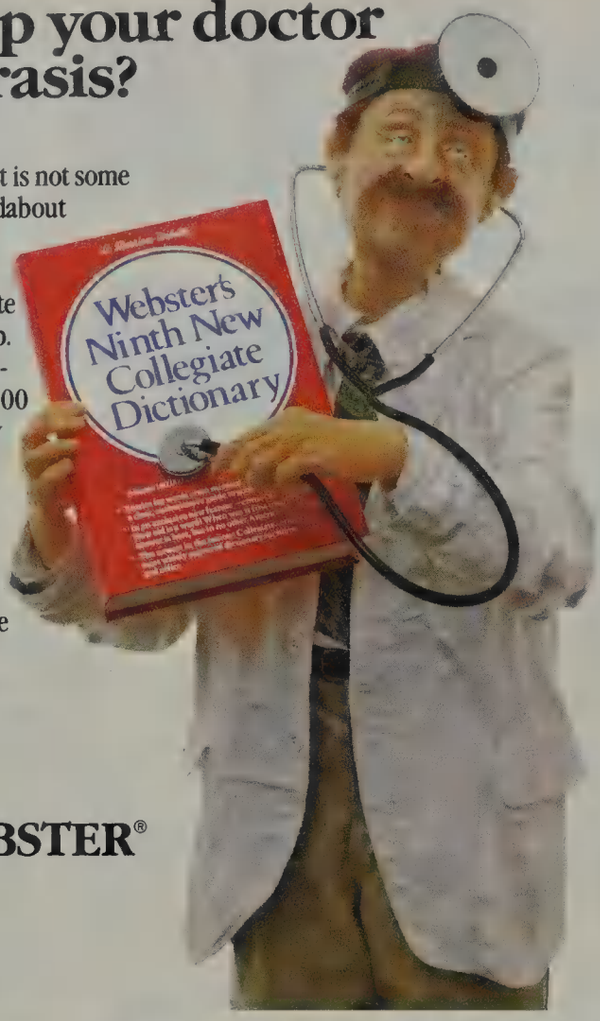

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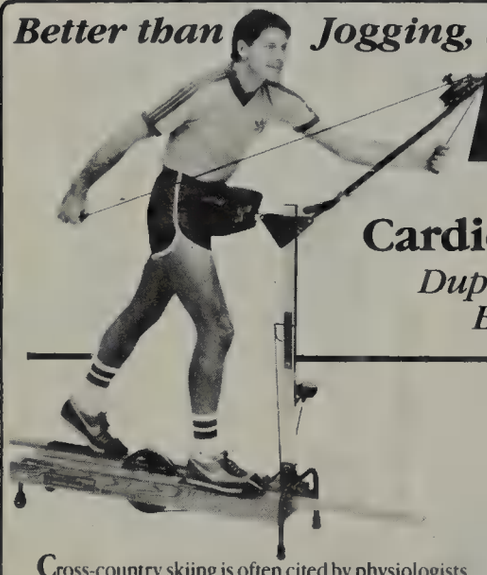

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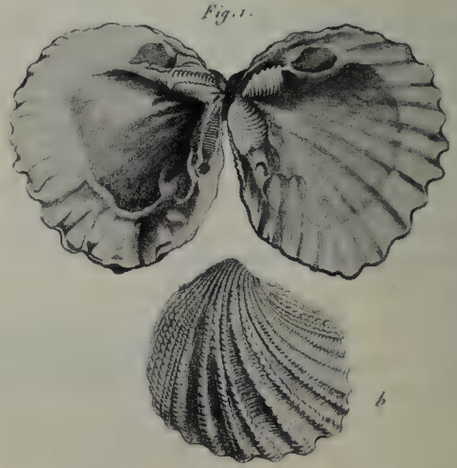
widely reported, discussed, and personally studied by the greatest naturalists of Europe, and then assimilated into each of several contradictory systems. Fifty years later, in 1865, a second discovery resolved the paradox generated by the first fact—and should have won, by Huxley's principle, a big and important victory for Darwin and evolution. It was welcomed, to be sure, but largely ignored. One foot soldier could not decide a battle waged on so many fronts.

Trigonia is a distinctive clam, thick shelled and triangular in shape. It flourished with dinosaurs during the Mesozoic era and then became extinct in the same debacle that wiped out the ruling reptiles—one of the five greatest mass dyings in our geologic record. No trigonian had ever been found in the overlying Cenozoic strata—the entire age of mammals (about sixty million years, as we now know). *Trigonia* had therefore become a valued "guide fossil"; when you found one, you knew you had rocks of the earth's middle age. Everyone (who was anybody) understood this.

Then, the nasty, ugly little—and quite undeniable—fact. In 1802, P. Péron, a French naturalist, found the shell of a living trigonian washed up on the beaches of southern Australia. Twenty-five years later, and following several failures, J. Quoy and J. Gaimard, naturalists aboard the *Astrolabe*, finally found a live trigonian. They had dredged for several days with definite purpose, but without success. Becalmed one night in Bass Strait and with little else to do, they tried again and brought up their single prize, a molluscan life soon snuffed and preserved in the (perhaps welcome) medium of the collector's trade—a bottle of alcohol. Quoy and Gaimard treasured their booty and wrote later:

We were so anxious to bring back this shell with its animal that when we were, for three days, stranded on the reefs of Tonga-Tabu,



Original figure of living trigonian by Lamarck (1804)

was the only object that we took from our llection. Doesn't this recall the ardent ell collector who, during seven years' war, rried constantly in his pocket an extraor-nary *Phasianella*, which he had bought twenty-five louis?

A simple story. A fact and a puzzle. *rigonia* had not disappeared in the great retaceous debacle, for it was hanging ugh in Australia. But no fossil trigonians d been found in all the strata in be-veen—throughout the long and well-re-rded history of the age of mammals ow called the Cenozoic era). Where ere they? Had they ever existed? Could ch a distinctive animal die and be re-rn (or re-created) later? The "Cenozoic p" became as puzzling and portentous the one later associated with Mr. Nixon d Ms. Woods.

Trigonia occupies a specially interest-g place in the history of biology because unexpected fact and consequent puzzle ose and prevailed at such an important me—at the dawn and through the great-t conceptual transition ever experienced the profession: from creationist to evo-tionary views of life. It also (or rather erefore) attracted the attention and mmentary of most leaders in nine-enth-century natural history. J.B. La-arck, most famous of pre-Darwinian olutionists, formally described the first ing trigonian. Darwin himself thought d commented about *Trigonia* for thirty ars. Louis Agassiz, most able and co-nt of Darwin's opponents, wrote the ma-r technical monograph of his generation the genus *Trigonia*.

The lesson of the living *Trigonia* can be stilled in a sentence: Everyone made the st of it, incorporating favorable aspects this new fact into his system and either noring or explaining away the difficul-es. *Trigonia* became an illustration for eryone, not a crucial test of rival theo-es. Evolutionists celebrated the differ-nces in form and distribution between an-ent and modern trigonians—and ig-ored the Cenozoic gap. Creationists ghlighted the gap and made light of the fferences.

Today, we remember Lamarck best as e author of a rejected evolutionary the-y based on the inheritance of acquired naracters (quite an unfair designation nce so-called Lamarckian inheritance epresents a minor part of Lamarck's own stem—this, however, is another story, r another time). But his day-to-day work post-revolutionary France involved the escription of living and fossil inverte-rates in his role as curator at the *Mu-eum d'Histoire Naturelle* in Paris. He herefore received Péron's precious shell

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for formal description, and he named it *Trigonia margaritacea* in 1804 (*margarita* is a Latin pearl, and the interior of a trigonian shell shines with a beautiful pearly luster). But since 1804 lay squarely between Lamarck's initial (1802) and definitive (1809) statement of his evolutionary theory, he also used his short paper on *Trigonia* to sharpen and defend his developing transmutationist views.

Most fossil trigonians are ornamented with concentric ridges at their anterior ends (enclosing the mouth and digestive apparatus) and radial ribs on the rear flank. A single strong rib usually separates these two areas. But all modern trigonians cover their shells entirely with radial ribs (although the embryonic shell still bears traces of the ancestral concentrics). Lamarck seized upon these differences to claim that changing environments had pressed their influence upon the shell. The shell had then altered in response and the animal within passed the favorable change to future generations by "Lamarckian" inheritance.

> They have undergone changes under the influence of circumstances that act upon them and that have themselves changed; so that fossil remains . . . of the greatest antiquity may display several differences from animals of the same type living now but nevertheless derived from them.

(But Lamarck had only demonstrate that the fossils looked different from th moderns. Any theory could account f this basic datum in the absence of furth information—evolution by use and disus by natural selection, or even re-creation b God for that matter.)

Lamarck then proceeded to extrac more from modern trigonians to buttres other pet themes. He was, for example, partisan at the wrong end of a great debat resolved a decade later to his disadvantag by Cuvier (see my column of Jun 1982)—does extinction occur in nature Human rapacity, Lamarck believe might exterminate some conspicuou beasts, but the ways of nature do not in clude termination without descent (La marck, as a transmutationist, obviousl accepted the pseudoextinction that occu when one form evolves into another). La marck gave the old arguments against ex tinction a novel twist by embedding hi justification within his newfangled evolu tionary views. How can extinction occur all organisms respond creatively to chang ing environments and pass their favorabl responses to future generations in th form of altered inheritance?

Yet Lamarck's conviction was sorel challenged by burgeoning data in his ow field of marine invertebrate paleontology So many kinds of fossils are confined t

The fossil trigonian (left) has both concentric and radial ribs, while the living trigonian (right) has only radial ribs.

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rocks of early periods. Where are their descendants today? Lamarck offered the only plausible argument in a world with few remaining terrae incognitae—they live still in the unexplored depths of the sea. Since Lamarck reveals his own discomfort with such an ad hoc solution in the form of a defense too often and too zealously repeated—recall Shakespeare's "the lady doth protest too much, methinks"—we may take as genuine his delight in *Trigonia* as a real case for a generalization devoutly to be wished: "Small species, especially those that dwell in the depths of the sea, have the means to escape man; truly among these we do not find any that are really extinct." Lamarck then ends his paper by predicting that a large suite of creatures apparently extinct will soon be found at oceanic depths. We are still waiting.

Since Lamarck's argument centers upon an explanation for why creatures still living yield no evidence of their continued vitality, we should not be surprised that the Cenozoic gap inspired no commentary at all. We must assume that trigonians spent the entire Cenozoic safe in the bosom of Neptune, full fathom five hundred or more, and unrecorded in a fossil archive of shallow-water sediments.

Charles Darwin, leading evolutionist of the next generation, selected yet another aspect of living trigonians—their geographic distribution—to bolster a different theme dear to his view of life. Darwin's creationist opponents, as we shall see, rendered the history of life as a series of static faunas and floras separated by episodes of sudden extirpation and renewal. To confute this catastrophist credo, and to advance his own distinctive and uncompromisingly gradualist view of nature, Darwin argued that the extinction of a group should be as smooth and extended as its origin. A group should peter out, dwindle slowly, decrease steadily in numbers and geographic range—not die in full vigor during an environmental crisis. What better evidence than a family once spread throughout the world in stunning diversity but now confined to one small region and one single species. In his private essay of 1844, precursor to the *Origin of Species* (1859), Darwin wrote: "We have reason to believe that . . . the numbers of the species decrease till finally the group becomes extinct . . . the *Trigonia* was extinct much sooner in Europe, but now lives in the seas of Australia."

(We now regard this claim for extinction of large groups as gradual dwindling in the face of competition from more successful forms—the central theme of chapter 10 in the *Origin of Species*—as among the least successful of Darwin's major arguments. Darwin may have feared that mass extinction supported the creationist view of debacle followed by divine reconstitution. But mass extinction may also clear the way for subsequent, vigorous periods of *evolution*. Again, as so often, Darwin's commitment to gradualism restricted his options for legitimate evolutionary hypotheses.)

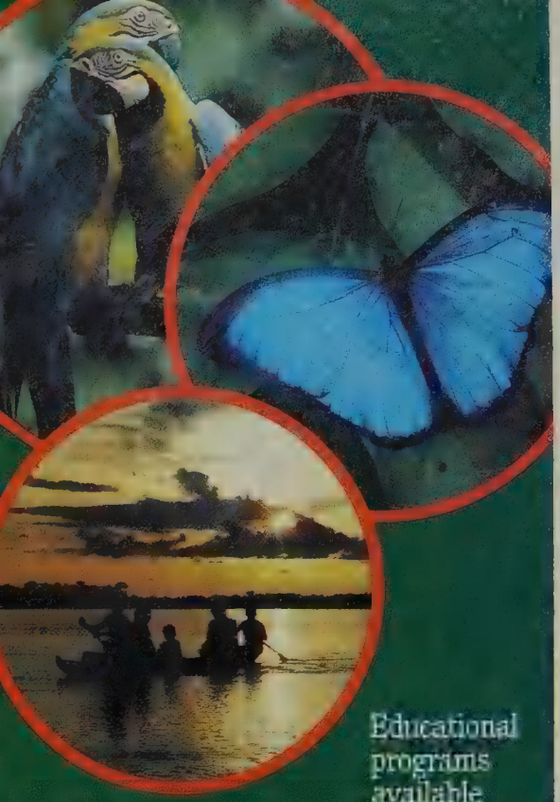
Darwin followed Lamarck in dismissing the Cenozoic gap as an artifact of our imperfect fossil record (I can, indeed, imagine no other option for an evolutionist committed to genealogical connection). But Darwin was explicit where Lamarck had been silent. Darwin also tried to accentuate the positive by arguing that the rarity of such long gaps strongly implied their artificial status. He wrote in the *Origin of Species*:

> A group does not reappear after it has once disappeared; or its existence, as long as it lasts, is continuous. I am aware that there are some apparent exceptions to this rule, but the exceptions are surprisingly few, so few that . . . the rule strictly accords with my theory.

Creationists, meanwhile, looked at *Trigonia* from the other side. They treasured the Cenozoic gap and found nearly everything else puzzling. The major creationist thinkers tended to agree that life's history had been episodic—a series of stages separated by sudden, worldwide paroxysms that removed the old and set the stage for the new. But they divided into two camps on the issue of progress. Did each new episode improve upon the last—was God, in other words, learning by doing? Or had life maintained a fairly consistent complexity throughout its episodic history? Progressionists and nonprogressionists found different messages in *Trigonia*.

James Parkinson, England's leading progressionist (though he switched allegiances later on), chose *Trigonia* as a premier example in his *Organic Remains of a Former World* (1811). He read the Cenozoic gap literally, extracting from it the congenial message that life's history features a series of creations not connected by ties of genealogy and physical continuity.

But *Trigonia* also presented a special problem for Parkinson. He argued that each successive episode of creation had been marked "with increasing excellence in its objects," thus matching in all ways but one the Mosaic progression from chaos to Adam as described in Genesis. "So close indeed is this agreement, that the Mosaic account is thereby confirmed in every respect except as to the age of the world" (a problem then resolved by a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orical interpretation of God's six cre- "days"). Now a *Trigonia*, as some say about roses, is a *Trigonia* (subtle- evident to the professional eye aside). should a modern shell with radial alone be better than a fossil represen- e with radials and concentrics? Why he modern versions superior, as Par- on's theory of progressive creation re- ed? Parkinson was evidently troubled. e summary statement to his three-vol- work, he devoted more space to *onia* than to any other genus. He hed at the one available straw, but ly without conviction. At least the ern trigonians are different. "*Raffini- st der Herrgott*" (Subtle is the Lord), nstein said later. We don't know why, different must be better:

shell, although really of this genus, is different species from any shell, which been found in a fossil state. So that none e species of shells of this genus, which known in a fossil state, have, in fact, found in any stratum above the hard k [the Cretaceous, or last period of di- urs], or in our present seas.

ouis Agassiz, most able of all tionists, followed Parkinson's personal e in reverse. He began as an advocate ogress in each successive creation and d by defending the earliest of God's tures as fully up to snuff (largely be- e he despised Darwinism with such ion and felt that any admission of ress would bolster the evolutionary e). For him, therefore, the apparent of improvement in modern trigonians d no problem, while the Cenozoic gap ght nothing but pleasure and con- ation. In the major pre-Darwinian k on these clams, his *Mémoire sur les onies* (1840), Agassiz argued explic- hat a Cenozoic gap, if conclusively af- ed, would effectively disprove evolu- (quite a cogent claim, by the way):

absence of *Trigonia* in Tertiary [Ceno- strata is a very important fact for dis- ons of the origin and relationships of ies of different epochs; for if it could day be shown that *Trigonia* never ex- throughout the entire duration of Ter- time, it would no longer be possible to tain the principle that species of a ge- living in successive geological epochs derived from each other.

ut Agassiz well understood the dis- forting uncertainty of negative evi- e. Find one nasty, ugly little Cenozoic nian tomorrow, and the entire argu- collapses. So Agassiz decided to r his rear and disclaim: No Cenozoic nian is dandy; but future discovery of nozoic trigonian would prove nothing. may, after all, ordain temporal con- tinuity among a group of related, created forms.

Although his passage is an exercise in special pleading, it also contains one of the most succinct and eloquent defenses ever written for the Platonic version of creationism.

> Although I now invoke this fact [the Cenozoic gap] to support my conviction that the different species of a genus are not variants of a single type . . . the discovery of a Tertiary trigonian would still not demonstrate, to my eyes, that the relationship among species of a genus is one of direct descent and successive transformation of original types. . . . I certainly do not deny that natural relationships exist among different species of a genus; on the contrary, I am convinced that species are related to each other by bonds of a higher nature than those of simple direct procreation, bonds that may be compared to the order of a system of ideas whose elements, developed at different times, form in their union an organic whole—although the elements of each time period also appear, within their limits, to be finished products.

In summary, as Darwin's revolution dawned in 1859, the supposedly pure and simple little fact of modern trigonians stood neither as arbiter nor slayer of theories but as touted support for all major conflicting and contradictory views of life—for evolution by Lamarckian and Darwinian agencies, and for creationism in both progressionist and directionless versions. How can something so important be so undecisive? Unless Huxley's heroic vision of raw empiricism triumphant rarely describes the history of ideas or even the progress of science. Percepts do not create and drive concepts; but concepts are not intractable and immune to perceptual nudges either. Thought and observation form a wonderfully complex web of interpenetration and mutual influence—and the interaction often seems to get us somewhere useful.

The *Trigonia* story has a natural ending that should be conventional and happy, but isn't quite. The resolution is not hard to guess, since Darwin's vision has prevailed. The elusive Cenozoic trigonian was found in Australian rocks—at just the right time, in 1865, when nascent evolutionism needed all the help it could get.

H.M. Jenkins, a minor figure in British geology, explicitly defended Darwin in describing the first Cenozoic trigonians. He interpreted the happy closure of the Cenozoic gap as a clear vindication of Darwin's characteristic attitude toward the fossil record and as direct support for evolution. Darwin viewed the fossil record as riddled with imperfections—"a history of the world imperfectly kept . . . of this history we possess the last volume alone. . . . Of

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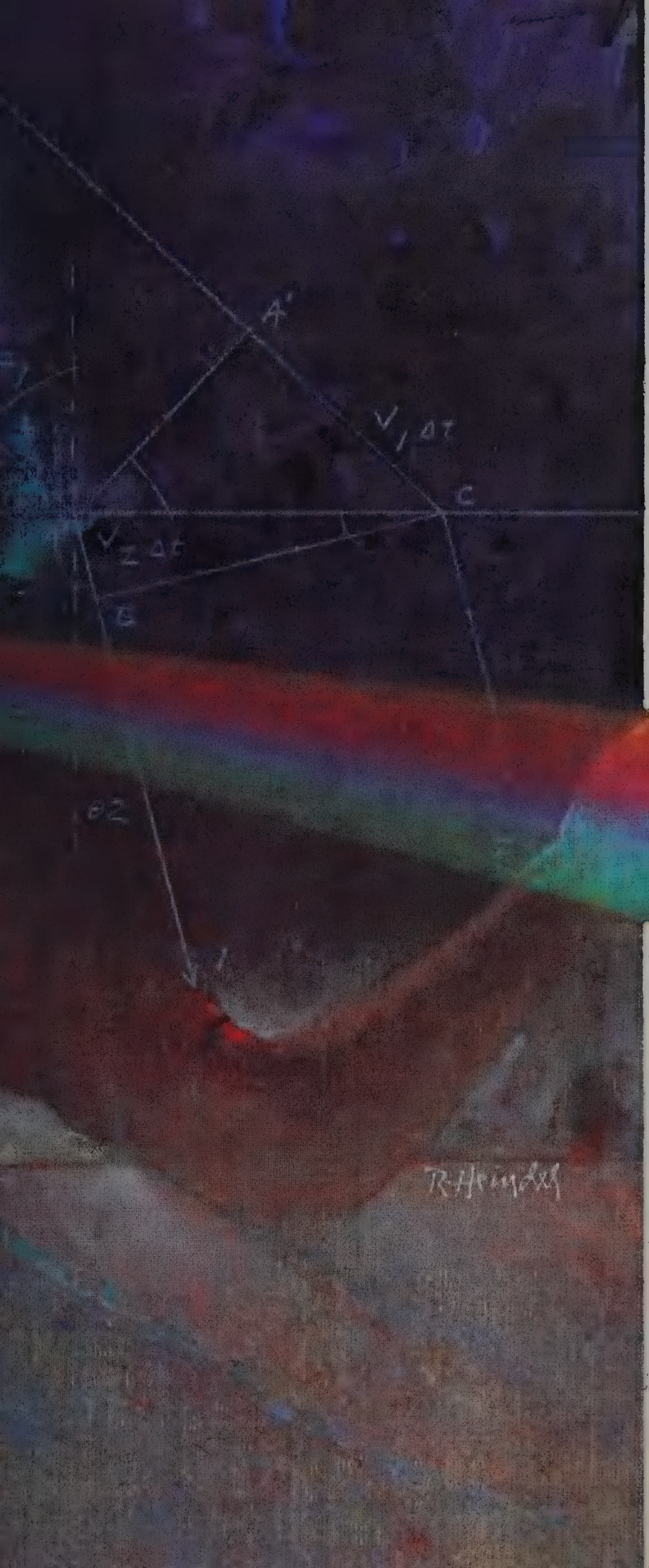

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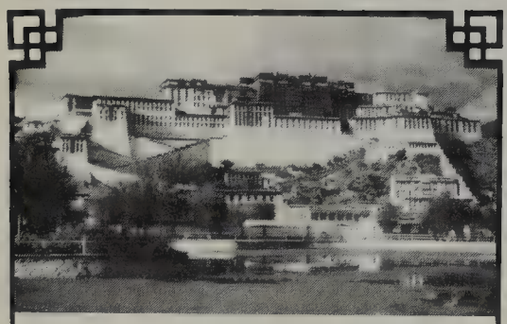

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this volume, only here and there a sho chapter has been preserved; and of eac page, only here and there a few lines" (*O igin of Species*, 1859). Gaps, as the ol saying goes, represent absence of ev dence, not evidence of absence. Jenkin wrote, linking the newly discovered Ceno zoic trigonian to this fundamental Da winian prediction:

Every paleontologist believes that, when genus of animals is represented by specie occurring in strata of widely different age it must have been perpetuated by some on or more species during the whole of the in tervening period. . . . The only rationa meaning that has ever been attached to th presumed general law . . . is that the pe petuation of the genus . . . has been due t "descent with modification." *Trigoni subundulata* [the formal name for the Ce nozoic trigonian] is one of the links hithert wanting; first, in explanation of the exi tence of the genus *Trigonia* in the Austra lian seas of the present day; and secondl as showing that the great gap which befor existed in its life-history was . . . simply consequence of the imperfection of ou knowledge of the geological record.

Finally, a personal confession in closing This column has been an exercise in sel indulgence and expiation. I put togethe the trigonian story at the very beginning o my professional career (when I was jus barely big enough to pay full price at th stadium). I published a rather poor ac count in a technical journal in 196 (frankly, it stunk).

I got part of the story right. I did recog nize that everyone managed to slot the liv ing trigonian into his system and that sim ple, single facts did not (at least in th case) undo general theories. But I got th end all wrong because the traditiona Huxleyan view still beguiled me. I told th happy ending because I read Jenkins quote and took it at face value—as an evo lutionary prediction fulfilled and an em pirical vindication provided. I forgot (o hadn't yet learned) a cardinal rule o scholarly detection: Don't only weig what you have; ask why you don't see wha you ought to find. Negative evidence important—especially when the record sufficiently complete to indicate that a absence may be genuine.

I now read the Cenozoic discovery quit differently, because I have confronte what should have happened but didn't. Darwin's vindication required a set o new, clean, pristine, unexpected facts then why didn't the Cenozoic trigonian in spire a wave of rejoicing? Darwin had pre dicted it; Agassiz had invested much hop in its nonexistence.

Sure, Jenkins said the right things in hi article; I quoted them and regarded m

sk as complete. But the key to the story s elsewhere—in the nonevents. Jenkins rote a two and a half page note in a minor urnal. No one else seemed to notice. arwin never commented, though the *Or-in of Species* still had several editions to n. *Trigonia* did not become a textbook xample of evolution triumphant. Most riously, Jenkins did not find the Ceno-ic trigonian. It was unearthed by Fred-ick McCoy, an eminent leader of Aus-alian science, the founder and head of e Museum of Natural History and Geol-gy in Melbourne. He must have known hat he had and what it meant. But he dn't even bother to publish his descrip-on. I should have taken my clue from the ening lines of Jenkins's paper, but I ssed them by:

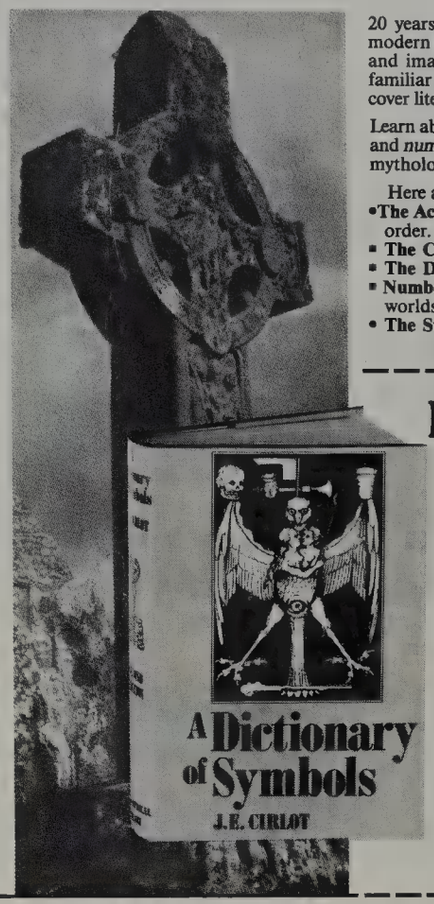
ne very interesting discovery of a species *Trigonia* in the Tertiary deposits of Aus-alia has in England remained entirely in e background, and I have been several mes surprised at finding students of Ter-ary paleontology, generally *au courant* ith the progress of their special branch of ience, unacquainted with the circum-ance. Its importance, in a theoretical oint of view, is beyond all question, hence e deep interest always exhibited by those whom I have spoken on the subject.

I had, in short, succumbed to the view I as questioning. I had recognized that the iginal discovery of the living trigonian ended no theory, but I had let the Ceno-ic fossil act as a Huxleyan nasty fact be-use Jenkins had so presented it. But hen we consider what the Cenozoic igonian did *not* provoke, we obtain a ore general and consistent account of e entire affair. The living trigonian anged no theory, because it could fit owever uncomfortably) with all major ews of life. The Cenozoic trigonian did ot prove evolution either, because gassiz's position of retreat was defen-ble (however embarrassing) and because volution was too big a revolution to rely itically on any one datum. *Trigonia* dn't hurt, but a multitude of fish were ying, and one extra clam, however clean nd pretty, didn't bring the meal to perfec-on (I shall anticipate a suitable recipe ext month, Mr. Sokolov).

Sherlock Holmes once solved a case be-use the dog didn't bark, but would have unded off had it been a dog. Nonevents atter, not only the new and nasty facts. Which reminds me: I must have looked at thousand periwinkles this morning. Still lefties. Maybe someday.

tephen Jay Gould teaches biology, geol-gy, and the history of science at Harvard niversity.

A Very Unusual Dictionary of the Origin of Symbols.



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A Black Hole for Sure?

Astronomers have the best evidence yet

by Stephen P. Maran

For years astronomers have tried to learn if black holes really exist. At least one observed object, the X-ray source Cygnus X-1 in the Milky Way, is widely regarded as a black hole, although that conclusion is not beyond doubt. However, recent observations provide near-certain evidence that a binary star associated with the powerful X-ray source LMC X-3, in the Large Magellanic Cloud galaxy, contains a black hole. (A black hole is a star that has collapsed to a diameter of just a few dozen miles. Its gravity is so powerful that not even a ray of light can escape, so the collapsed star cannot be seen—hence the term black hole.)

Since black holes are invisible, astronomers try to detect them indirectly by means of their effects on companion stars in binary systems (two stars that orbit each other because of mutual gravitational attraction). Most stars are members of binary systems, so we assume that many black holes are binary stars as well. When observing a binary system composed of an ordinary star and a black hole, we would expect to find the ordinary star and its unseen companion in orbit around a common center of mass. The orbital velocity of the ordinary star would help us estimate the mass of the unseen companion: the faster the ordinary star goes, the more massive its companion. The greater the mass of an ordinary star, the brighter it shines, so that a sufficiently high mass in a star whose light is not detected can be the telltale clue that the unseen star is a black hole.

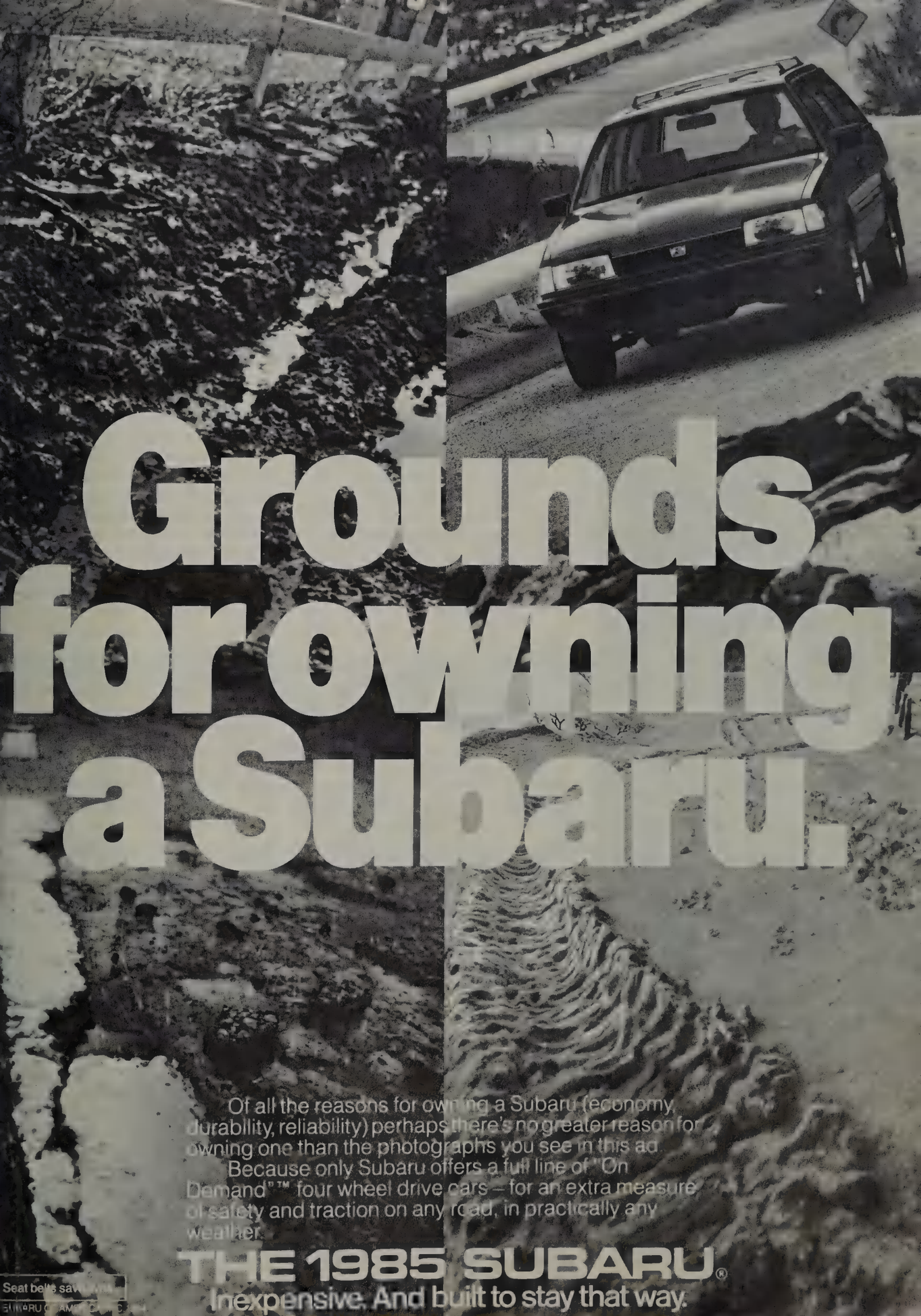
In close binary stars, mass is often transferred from one star to the other. If a close binary system contained a black hole, gas streaming toward the hole from the companion star would form a doughnut-shaped structure around the hole. As the gas in the doughnut spiraled inward, it would be compressed by the powerful gravity of the black hole and would get denser. Since compression produces heat, the doughnut gas would become very hot and would therefore shine brightly in X-rays. Thus, binary stars that produce X-rays are considered prime candidates for study as possible locations of black holes. In particular, the X-ray source Cygnus X-1, extensively monitored by Uhuru, an orbiting X-ray satellite observatory launched in 1970, was found to be associated with an unseen member of a binary star in our galaxy, the Milky Way. Analysis suggests that the unseen companion is probably a black hole, and recent textbooks describe it as such. Nevertheless, the unseen star in the Cygnus X-1 binary is much less massive than its visible companion, a supergiant star.

Conceivably, the unseen object in the Cygnus X-1 binary is a relatively ordinary star, lost in the glare of its companion supergiant. However, a variety of observations are inconsistent with this hypothesis, and most astronomers believe the object to be a black hole. Nevertheless, a nagging doubt remains. This concern about Cygnus X-1 does not apply to the unseen member of a binary system associated with the X-ray source LMC X-3. In that binary system, the unseen member is more massive than its visible companion star. If it were an ordinary star, it would far outshine its companion and would thus be seen.

The mere observation of X-rays from a binary star does not necessarily imply that a black hole is present, since two other types of small, dense stars—neutron stars and white dwarfs—are sometimes also surrounded by accretion disks (as the in-flowing doughnut-shaped gas structur are called) that glow in X-rays. Whi dwarfs, however, cannot exceed about 1 times the mass of the sun, and neutr stars probably do not exceed about 4 tim that mass, whereas even the visible mer ber of the LMC X-3 binary star excee these mass values.

The recent conclusion that the LMC 3 binary system contains a black ho comes after nearly fourteen years study. The LMC X-3 X-ray source w first observed on September 24, 1970, X-ray sensors on a Thor missile launch to an altitude of more than 185 mil above Johnston Atoll, in the mid-Pacif The observation revealed that the X-r emission from the Large Magellan Cloud was not a diffuse glow from t whole Cloud, as had seemingly been in cated by an earlier rocket observation. I stead, the X-rays appeared to come p marily from two localized sources in t Cloud, although their positions could n be accurately determined. In retrospe most astronomers agree that one of tho two sources was what we now call LM X-3.

In December 1970 and January 197 the Large Magellanic Cloud was repe edly scanned by Uhuru. Those scans tablished the existence of three princip X-ray sources in the Cloud, designat LMC X-1, LMC X-2, and LMC X-3. T positions of the sources were measur well enough to show that they were not c incident with any of the prominent stars cataloged nebulae in the Cloud. T Uhuru investigators, a team of astron mers from American Science and En neering (a private research and manufa turing company located in Cambridg Massachusetts), found that LMC X-1 a



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LMC X-3 (which correspond to the two X-ray sources detected by the Thor payload) "are two of the brightest X-ray stars ever observed." It thus became of great interest to learn what kind of stars they were. To do that, it was necessary to pinpoint the X-ray sources and learn which of the numerous stars in their general vicinities were associated with them.

The Uhuru measurements established that LMC X-3 was located within a limited area in the sky, called the error box. In 1973, astronomers from the Harvard-Smithsonian Center for Astrophysics, also in Cambridge, traveled to the Cerro Tololo Inter-American Observatory near La Serena, Chile, to investigate stars in the LMC X-3 error box. They found no evidence for an association of any observed star with the X-ray source, but pointed out a ninth-magnitude star as a promising candidate.

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Observations with two X-ray telescopes on the satellite Copernicus, also made in 1973, ruled out the ninth-magnitude candidate star. More precise than the Uhuru data, the Copernicus measurements reduced the size of the error box within which LMC X-3 must be located. The ninth-magnitude star was outside the borders of the smaller box.

Nevertheless, the reduced LMC X-3 error box did contain many stars much fainter than ninth-magnitude, five of which were observed from the South African Astronomical Observatory at the Cape of Good Hope. In November, 1974, the South African observers reported that one of the five, a previously uncataloged star of seventeenth-magnitude, stood out by virtue of its blue color and slight but certain increase in brightness over four nights of study. They proposed this star as the most likely candidate for association with LMC X-3.

As astronomers worked to pinpoint the optical counterpart of LMC X-3, interest in this X-ray source increased, thanks to additional measurements by Copernicus and by an X-ray telescope on the satellite OSO-7 (the seventh Orbiting Solar Observatory) during the 1970s. These findin showed that LMC X-3 had brighten since the Uhuru observations were ma in 1970–71 and now surpassed LMC X as the brightest X-ray source in the Lar Magellanic Cloud. The X-ray source tensity of LMC X-3 continued to chang varying by as much as a factor of ten, a cording to observations by the British ray satellite Ariel 5, reported in 1977. its brightest, LMC X-3 was perhaps t strongest stellar X-ray source yet foun

Further measurements from South A rica showed that the seventeenth-mag tude star seemed to vary erratically, light changing by as much as 60 perce However, there was no proof that it w the optical counterpart to LMC X-3, the South Africans had suggested. A rect correlation between changes in visi light and in X-ray intensity could be tak as proof of the association, but no eviden of correlated X-ray and visible lig brightness changes was obtained. Instea astronomers again turned to positio measurements in their search for the vi ble counterpart to LMC X-3.

A new, more powerful X-ray satelli HEAO-1 (the first High Energy Ast physics Observatory) scanned LMC X about 700 times during a three-month p riod in the summer and fall of 1977. Tho observations reduced the error box arou LMC X-3 by about a factor of three fr that based on the Copernicus measu ments. The seventeenth-magnitude va able blue star was one of the two bright stars in this smaller error box. A spect gram of the other star, obtained in Mar 1978, with the 141-inch telescope at t European Southern Observatory on Cer La Silla in Chile, indicated that that s was probably just a foreground object our own Milky Way, with no interesti properties. A second three months HEAO-1 observations narrowed t LMC X-3 error box still further. In th error box, the seventeenth-magnitude s was both the bluest and the brightest o ject. The hunters were closing in.

By November 1982 the identificati of the seventeenth-magnitude blue s and the X-ray source had been confirme thanks to measurements by the Einst satellite, the most powerful X-ray obser tory yet launched. The Einstein da showed that the star and the X-ray sou were coincident. During that month, cause the coincidence showed that t blue star was associated with the X-r source, a crucial series of thirteen spect grams of the star was obtained with t 158-inch telescope at Cerro Tololo. T observers, all experts on stellar spectr copy, were Anne P. Cowley (now at A

zona State University in Tempe) and David Crampton and John B. Hutchings, both of the Dominion Astrophysical Observatory in Victoria, British Columbia. They compared the thirteen spectra with each other and with a few earlier observations of the star, extending back to 1978, and discovered that the lines in the stellar spectrum move rhythmically back and forth in wavelength, with a cyclic period of about forty hours.

The cyclic changes in the spectral lines were strong evidence that the blue star follows an orbit with a period of about forty hours. The Doppler effect makes the lines shift with the same period.

The most striking aspect of that newfound orbital motion was its high speed. The seventeenth-magnitude blue star, with an estimated mass of about six times that of the sun, is charging around its orbit at more than 500,000 miles per hour, indicating that its unseen companion star, which has to fit inside that orbit, is even more massive; the best estimate is that the unseen star has ten solar masses. No star of that mass (other than a black hole) would fit in the orbit of the blue star, and even if it did, it would far outshine it; yet no other star is shining there.

Other evidence supporting the identification of the unseen object as a black hole comes from observations of the X-ray spectrum of LMC X-3, made with HEAO 1. According to Nick White, of the European Space Research and Technology Center in Noordwijk, Holland, and Frank Marshall, of the Goddard Space Flight Center in Greenbelt, Maryland, who made a careful study of LMC X-3, its X-ray spectrum agrees with theoretical predictions for the spectrum of radiation from gas spiraling in toward a black hole.

The powerful gravity of the presumed black hole would deform the seventeenth-magnitude blue star, elongating it in the direction of the black hole. Confirmation came in January 1983, when two astronomers at the University of Amsterdam reported on observations made with a sixty-inch telescope at the European Southern Observatory. They found that slight variations in the brightness of the star repeat periodically as it goes around its forty-hour orbit. The brightness changes indicate that the diameter of the star is larger along the axis connecting it to the hypothesized black hole than it is at right angles to that axis. As Cowley, of the spectroscopy team, wrote later, "The gravitational pull of the . . . black hole . . . is so strong that the star is distorted into an egg shape." When the axis is broadside to the earth, the egg-shaped star looks brighter because the long side of the egg is facing the earth; when the axis points roughly toward or away from the earth, the small end of the egg is facing us and the star seems fainter. The degree of distortion of the seventeenth-magnitude star, inferred from these variations in its brightness, is what would be expected if its unseen companion had ten times the mass of the sun.

In summary, much evidence supports the conclusion that the unseen object in the LMC X-3 binary system is a black hole: the rapid orbital motion of the companion blue star; the periodic brightness variations of the blue star, from which its distorted shape is inferred; the deduced mass of the unseen object; its small size inferred from the necessity of fitting within the small orbit of the blue star; that the object *is* unseen; and the strength and spectrum of the X-rays. In view of all this evidence, it seems that at least one black hole has now almost certainly been found.

Stephen P. Maran is a senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland. The opinions expressed here are his own.

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See Them Now

by Thomas D. Nicholson

Our best, if not the most comfortable, views of the stars usually come in the winter months. The main reason, of course, is the long winter nights, which enable us to see the sky in the early evening and late morning, dark hours when we are ordinarily stirring about. In addition, winter skies can be exceptionally crisp and clear, especially at their coldest when they hold so little moisture. Even the winter full moon cooperates, in that its very high path results in less scattering of moonlight in the lower, denser air through which the summer full moons shine all night long. Adding to all this, cyclical changes in the earth's orbit have combined in our era to point us, on winter nights, toward the brightest of our stars, which extend in a great sweep from Canopus in the south (below the Southern Horizon for most of us) to Capella in the north.

We will also enjoy the best of all the evening stars, Venus, in its optimal posture in the Northern Hemisphere's evening sky. This usually comes in February and March, when the ecliptic and orbit of Venus climb steeply upward from the west in the after-sunset sky. We owe to this Venusian posture our spectacular views of the planet this month, and of Mars near it, even though the latter, far from its opposition with the sun, isn't very bright.

Saturn and Jupiter improve their positions as morning stars this month. Saturn, in Libra, is up by midnight at month's end, the brightest "star" in its constellation. Jupiter, after passing the sun in mid-January, lets its brilliance speak for it in the morning. By the end of February it is easily seen in the southeast before sunrise.

Events in the calendar are given at local time unless otherwise indicated.

February 1: The waxing gibbous moon, three days past its first-quarter phase tonight, brightens early February nights. Today, it is near the border of Taurus and Gemini, midway between Taurus's reddish star Aldebaran, to the right, and the twin stars of Gemini, Pollux and Castor, to the left. The bright star above the moon, at the apex of a triangle that includes Aldebaran and the twins at its base, is Capella, in Auriga.

February 3: The brighter, fatter moon, below and in line with the twin stars, forms a threesome with Pollux and Castor.

February 4: Tonight's moon helps in finding the twins again, and also Regulus, the brightest star of Leo. The moon is centered between them, bright enough to dim the fainter, nearby stars. Regulus, to the moon's left, is under a circular group of stars (forming a backward question mark with Regulus as the dot), where the head of Leo would be.

February 5: Full moon, at 10:19 A.M., EST, is in Leo, above Regulus.

February 7: The moon is at perigee (nearest the earth) tonight. While the moon has pointed out the brighter stars higher in our sky this month, Venus and Mars have continued as evening stars fairly low in the west for several hours after sunset. Venus will be visible in twilight, and when the sky around it darkens, Mars is the only obvious object near it. If you observed the two planets in January, you will notice how much closer they are now. Venus passes Mars (conjunction) about 9:00 P.M., EST, moving east of it. But watch what happens later in the month.

February 8–10: The waning moon rises shortly before midnight on the 8th and 9th and drifts through Virgo on the mornings of the 9th and 10th, where it marks the bright star Spica. The moon passes th star from right to left on the 9th.

February 12: Last-quarter moon, a 2:57 A.M., EST, is in Libra, where you wi see it after it rises about an hour past mid night. The bright object above it is Saturn

February 13: The reddish star below th moon this morning is Antares, in Scorpius

February 15: The stars below the cre cent moon, in Sagittarius, trace the ou line of a teapot, with the moon very nea the peak of the lid. Look before daybrea dims the stars, even though the moon low. Venus and Mars, in the west afte sundown, haven't separated much sinc Venus passed Mars only a week ago. No Mars passes Venus, and the latter slow down in its easterly motion after greates elongation on January 22. In a few night you will see that they are slowly separa ing, with Venus to Mars's right again.

February 17: This is the last morning t see the late crescent moon before it be comes new. You might be able to find Ju piter above it in the early twilight, the firs time the planet has appeared as a mornin star this season.

February 19: Mercury is at superio conjunction with the sun, passing it fron right to left to enter the evening sky. Ne moon occurs at 1:43 P.M., EST, joining th sun in Aquarius.

February 21: Coming out from th sun's glare to the left, the new crescen moon should be visible after sundown near the southern border of Pisces, jus south of the vernal equinox.

February 22: The moon is near Mar and Venus until they all set at about 9:0 P.M. Look above the crescent where th sky is dark enough to see some stars. Mar will be nearest the moon, and brilliant Ve nus much higher.

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Membership Application 017

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The Thimble Collectors Club reserves the right to select specific designs included in this collection.

February 23: The moon is farthest from the earth about 1:00 P.M., EST.

February 24: The crescent moon crosses the border between Pisces and Aries, and the brighter stars of Aries, Hamal, and Sheratan are above it.

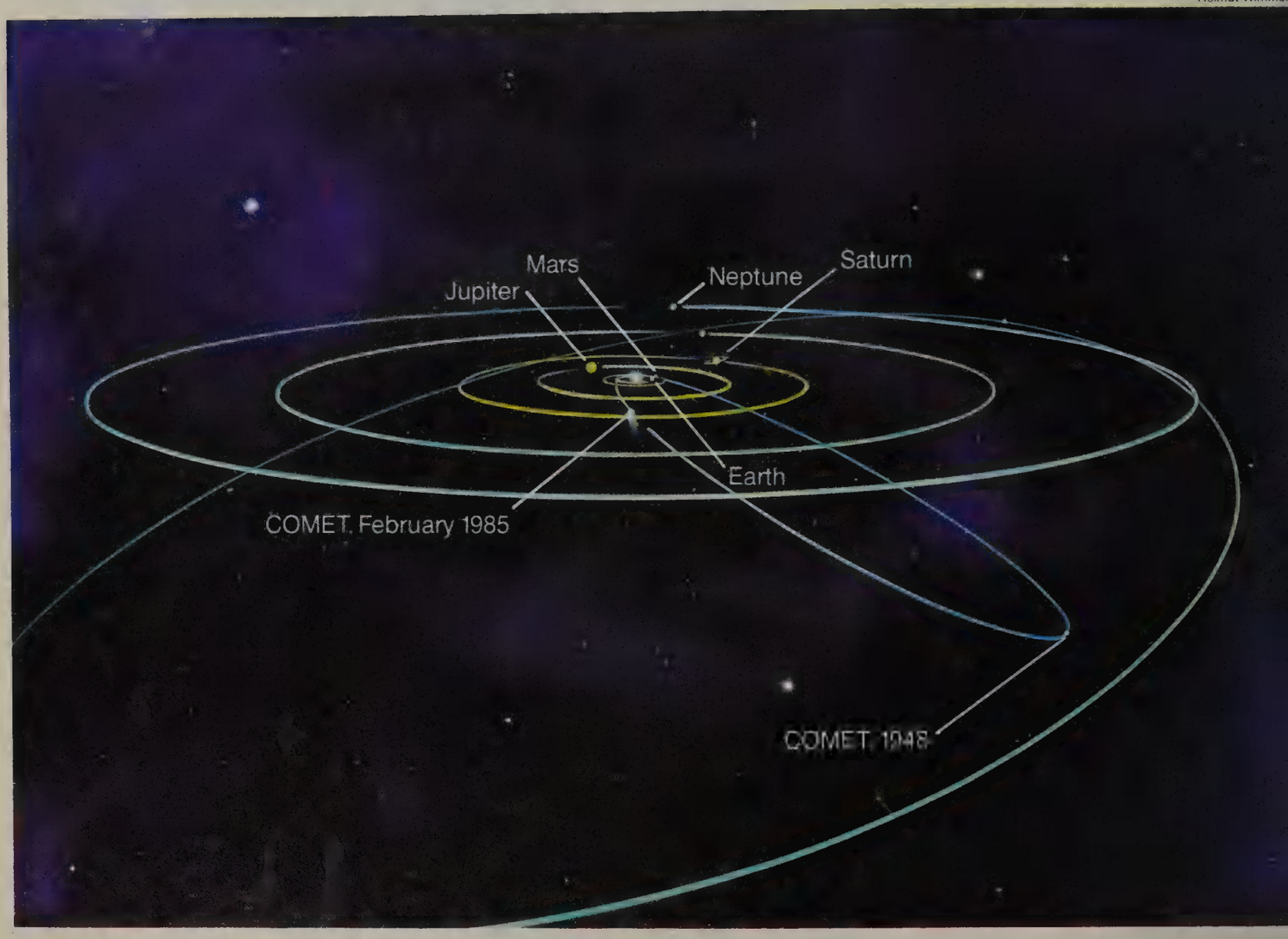
February 26: One day before first quarter, the moon enters Taurus and moves past the Pleiades, the fuzzy cluster of stars sometimes called the Seven Sisters. Look at them with binoculars if possible. Venus, below the moon early in the evening, is at greatest brilliancy in this evening cycle.

February 27–28: The first-quarter moon, at 6:41 P.M., EST, on the 27th, is above Aldebaran, Taurus's brightest star. On the evening of the 28th, the moon is nestled between the two stars that mark the Bull's horns.

Editor's Note: The Sky Map in the January issue shows the evening constellations and stars for this month and gives the times and dates for use.

Halley's Comeback

Helmut Wimmer



Halley's comet returns in 1985/1986. "Celestial Events" will document the comet's journey in a monthly countdown to show you where it is and where, when, and how it can be seen.

We begin the countdown with a view of where the comet has been following its last appearance in 1910. Since then, it has drifted slowly away from the sun in a long, narrow elliptical orbit, reaching in 1948 a point called aphelion, at which it was farthest from the sun, beyond the orbit of Neptune. On its current return, it has been gradually accelerating, and in February 1985, it will be near the orbit of Jupiter (but nowhere near the planet itself, as the illustration shows), heading toward perihelion (nearest the sun) on February 9, 1986. During subsequent months, we will depict the comet as it comes nearer the earth and the sun. Its position will be shown each month relative to the sun and planets, and then relative to the stars of our sky when the comet is expected to be visible to us, until it fades in the spring of 1986.

The very name of the legendary Halley's comet is synonymous with the awe, the mystery, and the drama associated with comets. The most famous of all such objects, with the longest record of appearances, dating back to 250 B.C., Halley returns to the earth's sky every 75 to 76 years. It is named after the eighteenth-century British astronomer Edmund Halley, who in 170 accurately predicted it would return in 1758, after a search of earlier comet sightings led him to believe that several were successive appearances of the same object at regular intervals.

In this month's illustration, the planets are located in their respective orbits, and the orbit of Halley's comet, inclined by seventeen degrees to the earth's orbit, is shown in relation to them. The position of Halley's comet in February is marked by a small cometlike symbol even though the object itself is still small and undistinguished, much like a faint, fuzzy star detectable only by modern instruments. Most of Halley's path lies south of the solar system's plane of orientation. Not until October of this year will the comet move north of the planetary orbits; in March 1986, it will move south again.

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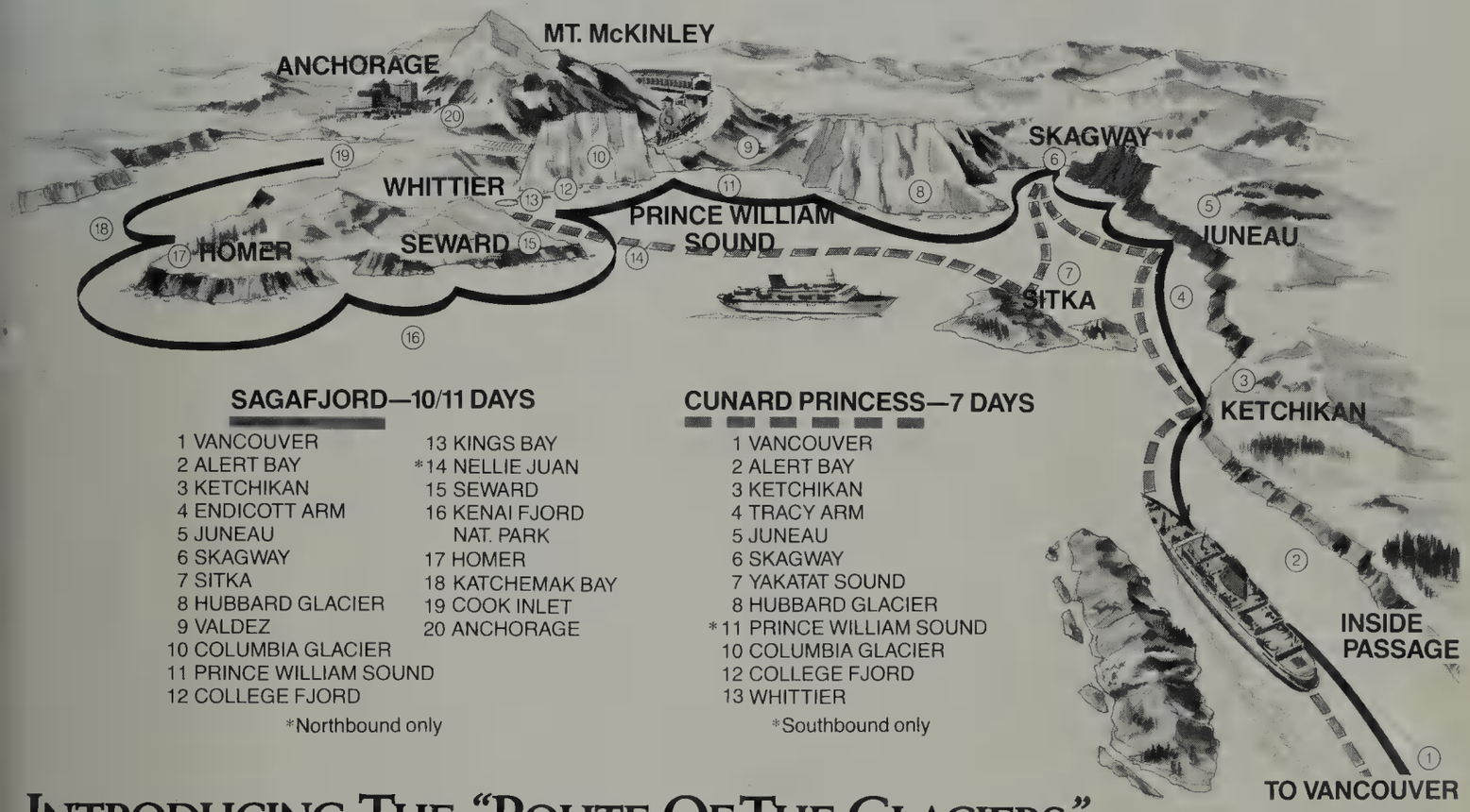

SAGAFJORD—10/11 DAYS

1 VANCOUVER
2 ALERT BAY
3 KETCHIKAN
4 ENDICOTT ARM
5 JUNEAU
6 SKAGWAY
7 SITKA
8 HUBBARD GLACIER
9 VALDEZ
10 COLUMBIA GLACIER
11 PRINCE WILLIAM SOUND
12 COLLEGE FJORD
13 KINGS BAY
*14 NELLIE JUAN
15 SEWARD
16 KENAI FJORD NAT. PARK
17 HOMER
18 KATCHEMAK BAY
19 COOK INLET
20 ANCHORAGE

*Northbound only

CUNARD PRINCESS—7 DAYS

1 VANCOUVER
2 ALERT BAY
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4 TRACY ARM
5 JUNEAU
6 SKAGWAY
7 YAKATAT SOUND
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*11 PRINCE WILLIAM SOUND
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Among the most populous roosts in the world are those of the red-billed quelea of Eurasia and Africa. These birds were photographed at night in Botswana.
Peter Johnson, NHPA

The Birds' Communal Connection

There is relative safety for seniors but some risk for juveniles when huge numbers of birds roost and flock together

by Patrick J. Weatherhead

My memories of Alfred Hitchcock's film *The Birds* have dimmed with the years, but I still remember my sense of wonder at scenes of birds converging, slowly at first, and then by the thousands. And a question persisted in the back of my mind: How did Hitchcock get so many avian extras to assemble in one place, at one time?

I did not have a plausible answer until several years ago, when I saw a communal roost site for the first time in Fort Campbell, Kentucky. I arrived at the site with some colleagues in the late evening before the birds began to appear. Although there was an impressive accumulation of droppings in the pine stand where the birds roosted, our lack of familiarity with roosts made us skeptical about the estimate, issued by the U.S. Fish and Wildlife Service, that the population numbered four million blackbirds and starlings. Our doubts vanished quickly when the sky began to fill with birds all flying directly to the roost and funneling into the trees. Long after there did not seem to be space for one more bird, they continued to pour out of the sky. Communal roosts, I decided on the spot, must have been what Hitchcock filmed.

Roosting is simply a daily period of inactivity—the equivalent in human terms of resting or sleeping. All birds roost; but some roost alone, some roost communally, and some switch from solitary to communal roosting on a seasonal basis. Even among the gregarious species there is further variation in the size, location, and timing of the roosting aggregation.

Attempts to generalize about the survival value of various roosting patterns seem doomed to failure. The size of communal roosting populations, for example, is one of the most variable features of the behavior. At one extreme are the small clusters of creepers or nuthatches that gather at night in tree cavities. At the other extreme are the most populous roosts, involving mind-boggling numbers of birds. Winter blackbird and starling roosts in North America regularly exceed several million individuals. In Africa, the red-billed quelea roosts in numbers estimated in the tens of millions. But the all-time record must go to the now-extinct passenger pigeon, estimated to have had single roosts of more than two billion birds covering an area of several thousand acres.

Both communal and solitary roosting species are well represented throughout the avian kingdom. And, as mentioned above, there are even some species that switch seasonally from solitary to communal roosting. The red-winged blackbird is an example of this behavior. During the breeding season, male redwings are the epitome of intolerance, each defending his territory against trespass by another male. Within weeks of the beginning and end of the breeding season, however, those same males roost side by side every night and remain gregarious throughout the non-breeding season.

Another variation in communal roosts is the choice of roosting habitats. This variation exists even within a single species. The European starling, for instance, has perhaps the most catholic taste in roosting habitats. I have seen starling roosts in cattail, reed, and alder stands in wetland habitats; in pine, cedar, maple, and mixed deciduous stands in upland habitats; and under bridges, on buildings, and in bell towers. When one adds to the list the cliff faces used by vultures, the is-

Barn swallows roost communally but only move close together in cold weather. They also forage together for flying insects.

Frith and Frith; Bruce Coleman, Inc.

lands used by sea birds, and the tree cavities used by creepers, it is apparent that communal roosting cannot be explained on the basis of the characteristics of any particular habitat.

What makes the question of why some birds roost communally so intriguing is the apparent disadvantage of that behavior. Birds are creatures of habit and return to the same roosting sites night after night, month after month, and year after year. Thus communal roosting would seem to provide would-be predators with a predictable and abundant source of food and hunters with an ideal target (witness the extinction of the passenger pigeon by humans). Another disadvantage of thousands of birds returning every night to the same location is that their search for food every morning takes them over the same general area in which they fed the previous day. This should put a substantial strain on the food supply, create competition between roost members, and require them to fly ever greater distances from the roost to find food.

Paradoxically, the same factors that seem to make communal roosting disadvantageous—the ease of predation and the difficulty of finding food—also form the basis of the two major traditional hypotheses proposed to explain the advantages of the behavior. The first of these, the predation-avoidance theory, presumes there is safety in numbers. Consider a bird that roosts alone. If found by a predator, the odds of that bird being eaten are necessarily 100 percent. If two birds roost together and a predator finds them, the odds that either individual will be eaten drop to 50 percent (since predators can presumably only grab one victim at a time), so the birds are clearly better off. Apply this reasoning to roosts that contain thousands or millions of birds. The odds of any individual roost member being taken by a predator are extremely small. The larger the roosting population, however, the easier it should be for predators to find the birds. The noise level, if nothing else, should attract attention. Thus the advantage to individuals in a communal roost only holds if the diminished risk from predators outweighs the increased risk of being ever more easily located as roost size increases. In other words, even if predators have no difficulty capturing some birds in a large roost, the other birds should continue to use that site as long as they are at lower risk than they would be if they roosted alone. Although no good data are available on the predation rates on communal roosting populations, I would expect them to be high. That roosting birds are often densely clumped, and so loathe to leave the roost that humans can capture them by hand, suggests that the birds are easy pickings for skillful predators.

Related to the advantages birds realize by reducing individual predation risks are the advantages they derive while foraging. Most species of communally roosting birds feed in flocks. As in a communal roost, individuals in a flock reduce their

Each black vulture picks its own cactus as the sun goes down in the Sonora Desert.

M.P.L. Fogden

chances of being the victim should a predator attack. In addition, there is evidence that birds in a flock can more quickly detect the approach of predators than can individuals that feed alone, presumably because more eyes are on the lookout. Using trained goshawks as experimental predators, an ornithologist who tested this hypothesis found that larger flocks of wood pigeons detected an approaching goshawk at a greater distance than did smaller flocks, reducing the goshawk's hunting success. Not only are more eyes an advantage in detecting predators; they also enable each bird to spend more time looking for food. The same advantage holds for a bird in a mixed-species flock. Another researcher found that when downy woodpeckers joined flocks of chickadees, titmice, and nuthatches, they reduced their vigilance and increased their foraging rate.

An additional advantage of feeding in flocks is that short-lived food supplies, such as swarms of insects, schools of fish, ripening fruit, patches of seeds, or the carcasses of dead animals, can be more effectively located. The sites where these sources are found are often too large for one individual to search thoroughly in the short time before the food patches are discovered by other animals with similar feeding habits. The suggestion has therefore been made that by feeding in flocks, individuals benefit from the search effort of other flock members despite the disadvantage of competition from them.

Granted that foraging birds can reduce their risk of predation by feeding in flocks, why is it necessary for the flocks to congregate each evening for roosting? One hypothesis is that the roost is used as an information center—a place to learn where the food is located. Observation of a flock of feeding birds indicates that flock members do use each other to locate food. When a few individuals focus their attention on one patch of ground, other birds quickly congregate there. This is the same imitative behavior that causes vultures to gather rapidly at a fresh kill and ducks to be attracted to hunters' decoys. If birds feeding in flocks can find local food patches more efficiently than birds feeding alone, then, according to the information-center hypothesis, those flocks should also be better able to locate food patches over a wider expanse. By roosting together, birds can take advantage of the search by fellow roost members to locate food. An entire flock or a flock member that returns to the roost without finding food need only follow more successful individuals the next day to locate new food patches. Just as those who argue that the principal advantage of communal roosting is the avoidance of predation also concede a secondary advantage to greater success in finding food, so proponents of the roost as an information center concede that a secondary advantage may be the avoidance of predation.

A fundamental problem with the information-center hypothesis is that it con-

Within almost all avian families there are examples of communal roosting. The gregarious rainbow lorikeet of Australia is one of them.

Stephen J. Krasemann

fers an advantage on individuals that "cheat": birds that return to the roost but never share information about food patches they have successfully located. A related question is how birds recognize individuals that have foraged successfully. (Birds don't belch or pat their stomachs after a good meal, so no one knows how they might indicate they have fed well.) The "cheating" problem applies to the older birds, which are more skilled at finding food than their juniors. These older birds would seem to be better off avoiding communal roosts rather than using them and always having to share their food with younger birds that follow them. In large roosts those younger birds are not necessarily related to the older birds, so it is not a case of the older birds sharing food with their offspring.

As I continued to ponder why some birds roost communally, it occurred to me that the shortcoming of the two main hypotheses—predation avoidance and the communal roost as an information center—was that both assume that all birds in a roost are there for the same reason. If one assumes that different individuals might benefit in different ways from roosting together, one arrives at an explanation for communal roosting that is more consistent with both fact and theory.

The problem with the information-center hypothesis is that older birds, which many studies—ranging from pelicans to blackbirds—show are consistently better at finding food, do not seem to gain any advantage from communal roosting. But older birds usually dominate younger ones and are therefore able to displace them from preferred perches in a communal roost. This ability would be highly advantageous if birds spending the night on certain perches were more vulnerable to predators. We know that among birds that breed in colonies, nests on the periphery of the colony usually suffer the highest predation rates, and the suggestion has been made that competition for central nest sites probably forces the younger birds to the periphery of the colony. Such a pattern may also prevail in communal roosts, since a predator entering a roost would probably attack the first birds it encountered on the periphery. Thus, a roost can be thought of as a series of concentric layers of birds, with the lowest-ranking, younger individuals in the outermost layer and the most dominant, older individuals in the center. The efforts of the birds in the vulnerable outer layers to insinuate themselves into the more secure inner layers could account for the high densities of birds in many communal roosts.

Given the advantage to the birds in the center of a roost, why do individuals forced to stay on the periphery join a roost at all and run the higher risk of predation? If dominance and foraging skills are strongly correlated, then the peripheral roost members would be those most in need of information regarding the location of food. As long as the advantage of following dominant roost members to feeding sites outweighs the risks of being killed by a predator, subordinate birds would also benefit by membership in a communal roost. This supposition, combining elements from the two traditional theories about communal roosting, is what I will refer to as the two-strategies hypothesis.

Although we need studies designed to test the specific predictions of this two-strategies hypothesis before its validity and general application can be evaluated, some promising evidence already exists. A study of rooks in East Lothian, Scotland, showed that the older birds dominated younger birds, as evidenced by the older birds' ability to displace the younger birds from perches higher in the roost trees. The researcher interpreted the preference for higher perches as evidence that higher positions were less vulnerable to terrestrial predators, although no data in support of that interpretation was provided. Studies

A flock of yellow-headed blackbirds feeds on insects and seeds. The birds nest in colonies but roost both in groups and solitarily.
Galen Burrell

of brown-headed cowbirds roosting in oak trees on the Rice University campus in Houston, Texas, and studies of red-winged blackbirds roosting in a stand of cattails in a city park in Ottawa, Ontario, have also found that older birds use their dominant positions in the hierarchy to gain access to these presumably safer roost sites. The roosts in both of these studies—unlike the rook roosts in Scotland—were stratified horizontally, rather than vertically, with a disproportionate number of older birds occupying central positions. The advantage to older birds of access to safer roost sites is consistent with the two-strategies hypothesis for communal roosting outlined above.

A dominance hierarchy has also been observed in a mixed-species roost of egrets, herons, and other species in San Blas, Mexico. In this instance, dominance was determined by species rather than age, with the snowy egrets and great egrets displacing the other species of egrets and herons from the higher perches in the roost trees. Again, the higher perches were thought to be preferred because individuals roosting there would be less vulnerable to predation. Interestingly, a study of some of the same species of egrets and herons in Panama revealed that three of the heron species increased their foraging success by feeding near the snowy egrets. When dummies of each species were placed in foraging areas, many more birds were attracted to the artificial snowy egrets than to dummies of the other species, indicating that the snowy egrets were being used to locate food. If subsequent observation at the roosts in Mexico and Panama reveals that the subordinate species in the roost follow the snowy egrets to feeding areas, the two-strategies hypothesis will gain strength.

The best evidence in support of the two-strategies hypothesis was brought to my attention by Danish ornithologist Anders Pape Møller. In a recent study of roosting swallows in Bronderslev, Denmark, Møller found that older birds not only had greater feeding success than juveniles; they were also able to displace juveniles from the lower perches in the reeds in which they roosted, forcing the younger birds to roost in positions that appeared to make them more vulnerable to predators.

Møller's study recorded the foraging success of flocks of swallows feeding away from the roost during the afternoon. Observation at those sites the following morning revealed that the greatest increase in the number of foraging birds occurred where the foraging success had been highest the previous afternoon, and that the increase in flock size was due primarily to an increase in the number of juvenile birds. Interestingly, this pattern of an increase in flock size at sites where foraging had been successful the previous day only held when Møller considered the afternoon foraging success of adult swallows, not juveniles. One might infer that, in some manner we do not yet understand, juvenile swallows in the roost were able to recognize adults that had foraged successfully that day and to follow them to those feeding sites the next morning. That the successful juvenile birds were not followed, in turn, to their feeding areas may indicate that a well-fed adult is a more reliable source of information regarding feeding sites than is a well-fed juvenile.

Because the evidence available to date is consistent with the two-strategies roosting hypothesis, one might expect that the

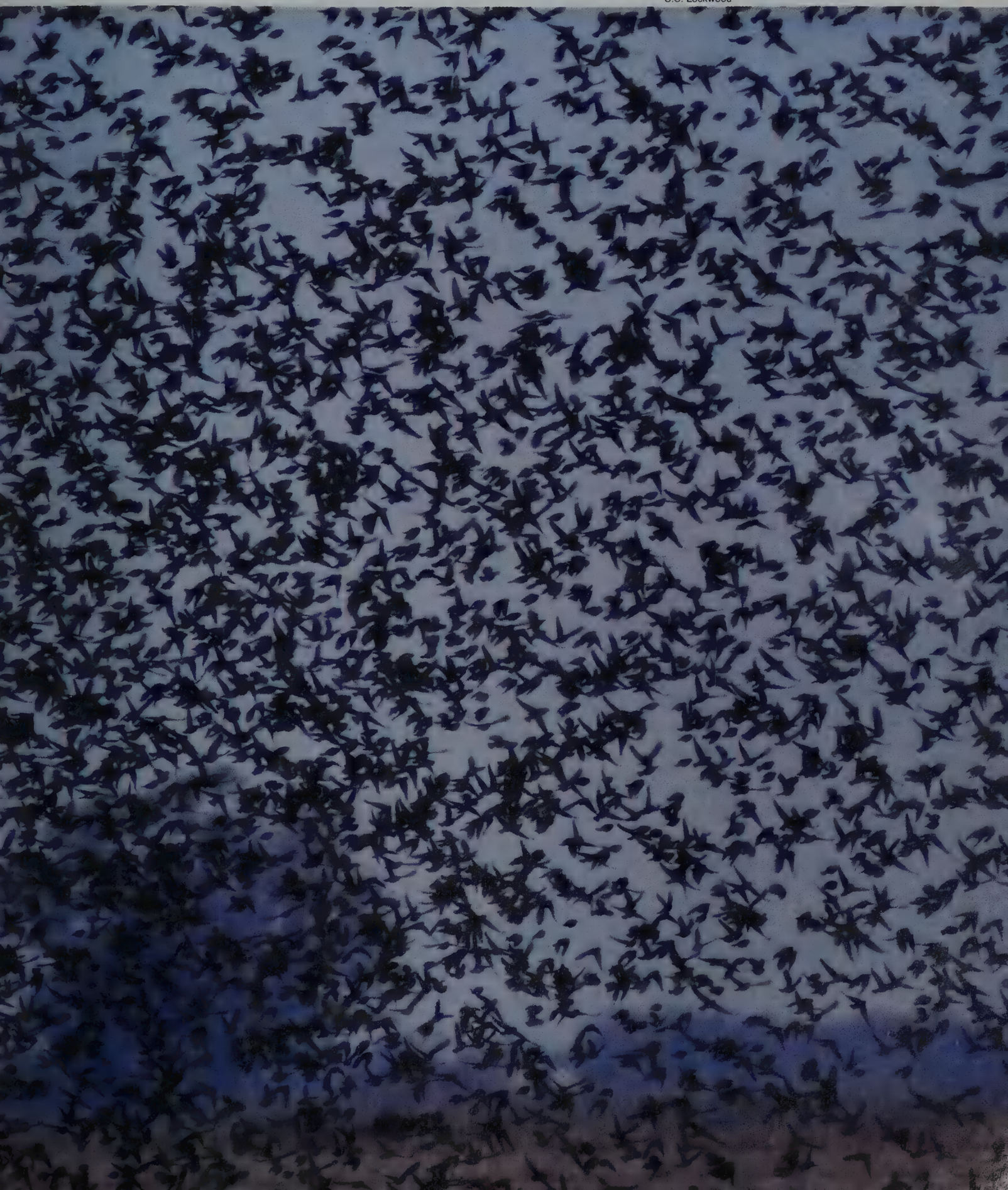
hypothesis will prove to be valid under most circumstances for most species. But even general explanations of natural phenomena have many exceptions. For example, I have largely ignored the role of temperature in a communal roost. Because their collective body heat loss may raise the temperature within the roost, birds roosting together probably lose less energy at night than those roosting alone. However, independent studies of jackdaws and starlings have shown that the energy the birds save by roosting together does not compensate for the energy expended in flying to and from the roost each day. Nevertheless, for species such as pygmy nuthatches, which gather in well-insulated tree cavities and pack in so tightly that they maintain body contact, energy savings may well be the primary benefit of roosting. Species such as tree swallows, barn swallows, and bank swallows regularly roost communally but form tight clusters within the roost only in very cold conditions. Therefore, communal clustering and communal roosting should perhaps be considered separate phenomena.

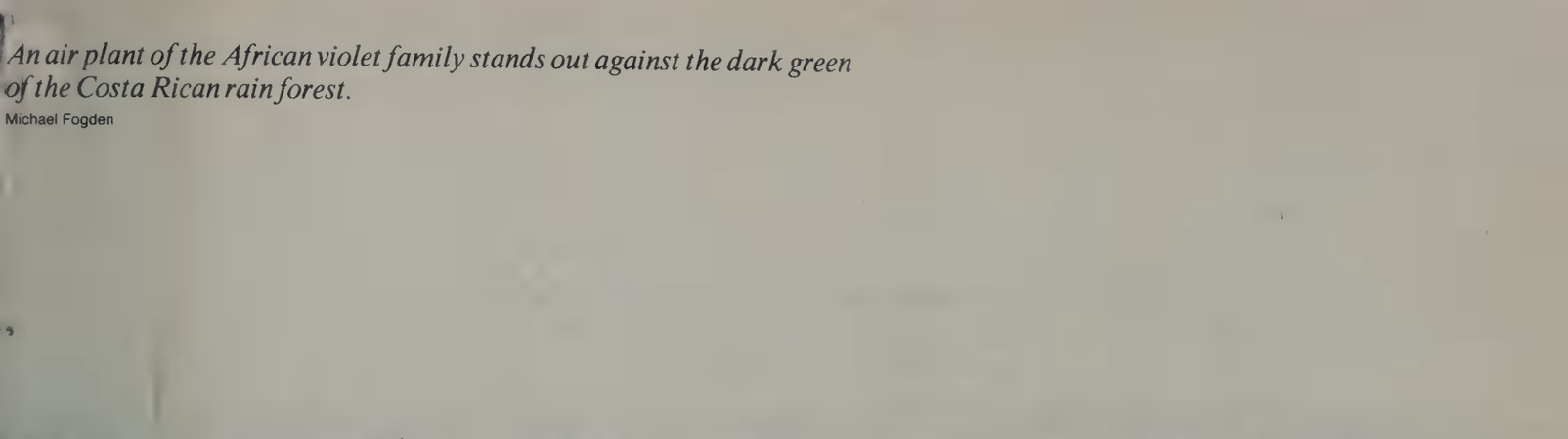
This discussion of communal roosting has so far been restricted to birds. But bats also often roost communally. Spectacular aggregations of millions of Mexican free-tailed bats can be seen in the Carlsbad Caverns in New Mexico. Whether all species of bats that roost together do so for the same reasons, and whether those reasons are the same as the ones influencing the behavior of birds, is not known.

My expectation is that as empirical studies of roosting birds catch up with the new two-strategies theory, we will see both general patterns and numerous exceptions. The generalizations would necessarily have to involve predation and food finding because large numbers of birds require large amounts of food—and represent just that for predators. The exceptions to the theory would include those species that huddle only for warmth and probably some species that we predict should roost communally but do not. Careful study of species of the latter type will determine whether they are exceptions that prove the rule or instances that disprove the rule altogether. □

Blackbirds fly across a Louisiana field on their way to their roosting site. The numbers in which they and the red-billed quelea roost are probably among the highest of any extant species.

C.C. Lockwood





An air plant of the African violet family stands out against the dark green of the Costa Rican rain forest.
Michael Fogden

Roots That Go Out on a Limb

In the rain forest, trees tap into air plants that mass on their branches

by Nalini M. Nadkarni

Seventy feet above the floor of a tropical rain forest, a pink orchid blooms in a pad of soft, gray-green moss held aloft by a stout tree limb. Nestled among the spiky, swordlike foliage of bromeliads, tiny-leafed ferns flicker in the sunlight. A bird's-eye view of the forest canopy offers an aerial parade of plants in extraordinary variety, hidden to all but the keenest observer on the ground below. While they are sometimes known as air plants, these treetop dwellers are generically classified as epiphytes (*epi*, "upon"; *phyte*, "plant") because they grow, not in the earth, but upon the branches and trunks of supporting host trees.

Epiphytes have fascinated botanists and horticulturists for a century, not only because of their diversity—some 30,000 species of plants grow epiphytically—but also because their unexpected presence in the forest canopy of foliage seems an incongruous whimsy of nature.

Contemporary biologists are particularly interested in the place that epiphytes hold within the self-contained ecological community of the forest canopy. Paradoxically, in forests where heavy rainfall leaches nutrients from soil, vegetation grows in profusion. What role do epiphytes play in this highly efficient nutrient-conservation system?

Until recently, epiphytes were thought to be somewhat superfluous to the ecosystem. Traditionally, their relationship to host trees has been regarded as nutritionally neutral: they neither harm nor particularly help one another. Now there is new evidence that epiphytes may offer their hosts direct nutritional benefit in return for treetop support.

Epiphytes take only physical support, not nutrition, from their host trees. Unlike true parasites, such as mistletoe (whose roots burrow through bark and tap into the host tree's vascular system), epiphytes have no direct access to nutrients within their hosts. Nor do they have root systems that, like vines and lianas, compete with surrounding vegetation for their share of nutrients on the forest floor. Rather, epiphytes take sustenance from the trace amounts of minerals in rainwater and dust particles that fall upon them as these nutrients pass through the treetops.

Epiphytic plants of the rain forest canopy encounter feast-or-famine conditions. The supply of essential nutrients, such as nitrogen, phosphorus, calcium, and other mineral elements, is erratic and uneven. Although rain passes through the canopy with some regularity, it moves over branches and trunks rapidly and leaves little residue. Compared with the warehouse of nutrients on the forest floor, the canopy cupboard is rather bare.

In the face of this sporadic supply of nutrients, many epiphytes in temperate and tropical regions have developed structural and physiological characteristics that allow for efficient nutrient gathering and storage. These mechanisms include such structures as absorptive trichomes, hairlike structures on the surface of leaves that aid in water retention, and leaf formations that actually cradle and save water and nutrients. Some of the lower orders of epiphytes, such as mosses, liverworts, and some lichens, are characterized by "poikilohydric" foliage: special guard cells on the plant's surface quickly absorb moisture when it is available, immediately shut down to prevent water loss when exposed to extremes of heat, and then rapidly resume metabolic processes when moisture is again available. These qualities provide some epiphytes with a degree of tolerance to the extreme environmental conditions of the exposed canopy.

As a graduate student in forest ecology at the University of Washington, I studied the relationship between epiphytes and their host trees and focused in particular on how nutrients are stored and then transferred, or cycled, throughout the forest canopy. My investigations were conducted on the west coast of the Olympic Peninsula in Washington, in a classic example of a temperate rain forest. The Olympic Rain Forest, as it is popularly known, lies within the borders of Olympic National Park and shares numerous characteristics with tropical rain forests: it is a multistoried forest of massive evergreens, with abundant rainfall (nearly 150 inches a year) and highly leached, nutrient-poor soil.

The profusion of epiphytes in the Olympic Rain Forest is greater than in any other temperate rain forest in the world and even rivals that of tropical rain forests of South and Central America. Epiphytes upholster the branches and trunks of the Sitka spruce, Douglas fir, red alder, and black cottonwood trees. On the big-leaf maples that grow in wet lowland sites along the park's Hoh River, epiphytes festoon tree limbs like damp green fur, and thick mats of decomposing epiphytic matter, or detritus, form cushions as much as ten inches thick.

The epiphytes of the Olympic Rain Forest belong mainly to the nonvascular and the lower order vascular plants: lichens, mosses, club mosses, and liverworts. With the exception of the licorice fern, higher order epiphytes, such as the orchids, bromeliads, and gesneriads found in tropical regions, do not grow there. The Olym-

Gathering moisture and dissolved minerals from the continuously humid atmosphere, epiphytes, or air plants, cloak the trees in the Monteverde cloud forest of Costa Rica.

Richard La Val

pic Rain Forest does not display the colorful patchwork of flowering epiphytes found in the tropics, yet the diversity of epiphytic mosses and liverworts is remarkably high; more than 130 epiphytic moss species have been documented there. Among the more common species are the *Eurynichium oreganum*, *Isothecium stoloniferum*, and the stepping-stone moss (*Hylocotnium splendens*).

In the past biologists were limited to studying canopy ecology by climbing trees with spikes and ladders, constructing aerial catwalks or free-standing towers, or by simply cutting down trees. Obviously, these methods not only restricted movement within the canopy but also frequently harmed or even killed the trees. In recent years, however, a number of imaginative and intrepid biologists have applied advanced rock-climbing techniques to gain safe access to the treetops and easy mobility within the canopy. Now the world of epiphytes is accessible to all but the most acrophobic.

Climbing into the canopy is quite simple. A sturdy nylon cord is shot over a branch with a crossbow or slingshot, then tied to a standard mountain-climbing rope. This rope is then pulled over the branch and anchored at the base of the trunk or that of a neighboring tree. Wearing a seat harness and leg loops and assisted by special sliding aluminum clamps called Jumar ascenders, the climber can inch up the rope with a minimum of effort. By shooting lines from treetop to treetop, one can use the ascenders to move laterally across the canopy.

Once within the canopy, it is possible to estimate the magnitude of the entire epiphytic community by weighing sample epiphytic mats from selected trees of differing sizes. For example, the fresh weight of live epiphytes on a typical big-leaf maple (height, sixty feet; diameter, forty inches) was 100 pounds. Extrapolating from these figures to the entire maple grove, the dry weight of epiphytes totaled 6,000 pounds per acre, four times the weight of host tree foliage calculated by other researchers in similar forests.

Mineral elements held within this mass of epiphytic growth constitute a considerable portion of the canopy's pool of available nutritional resources. Some of these nutrients, intercepted from rain or dust and held temporarily in epiphytic tissues, are transferred, or cycled, to other parts of the ecosystem: epiphytes fall to the forest floor, decompose, and join the pool of nutrients in the soil; their nutrients are leached from the canopy via rainfall, or the plants are eaten by herbivorous insects and deposited as they die or defecate.

As I continued to peel epiphytic mats from the trees' surface, I made a totally unexpected discovery that suggested yet another means of nutrient transfer. Under the epiphytes, an extensive network of roots crisscrossed the branches and trunk of the maple tree where I was working. The roots penetrated mats of decomposing epiphytes and ranged in size from tender white root tips with tiny root hairs to woody roots three inches in diamete They appeared only beneath layers moist organic matter and were abse where epiphytes tapered off on upp trunk and outer branch surfaces.

Like a spider racing to build its web, slid over the trees on my climbing rop and traced each system back to its point origin: the junction of a branch system the host tree itself. These were map roots. Greatly excited, I realized that he was a shortcut in the rain forest's nutrie cycling system. Host trees were capable tapping the arboreal cupboards in the own crowns.

A typical big-leaf maple with heavy f liage and a diameter of approximate forty inches had canopy roots originati at eighteen points along the trunk, an where from three to forty-five feet abo the forest floor. Some of the roots e

By sprouting roots directly from trunks and branches, rain forest trees exploit the nutrients contained in the cushiony mats of live and decaying epiphytes. Below: A layer of epiphytes has been pulled back to expose a tangle of aboveground roots.

Richard La Val

ended as far as twenty feet out along branches before epiphytic mats and roots erminated. Three canopy root systems branched off in an upward direction; two had descended down the trunk completely and penetrated the forest floor below with no alteration in appearance.

I was eager to learn the extent of this phenomenon. Nowhere in the literature on epiphytes was this hidden root system recorded. How common was canopy rooting? Which trees put forth such root systems? What kind of roots were they, and what did they do? In the following weeks more and more lines dangled from the forest canopy as I expanded my treetop surveys. Ropes were tossed and tied; tools and supplies raced up and down guidelines.

Four of the seven common tree species that grow in the Olympic Rain Forest produce canopy rooting: the big-leaf maple (*Acer macrophyllum*), vine maple (*A. circinatum*), mature red alder (*Alnus rubra*), and black cottonwood (*Populus trichocarpa*). Anatomically, canopy roots were identical to their belowground counterparts. Root sections observed under a microscope revealed cortical cells, xylem and phloem bundles, root caps, and root hairs, all common root structures necessary for absorption and conduction of water and nutrients.

Canopy roots also exhibited the same symbiotic relationships with microorganisms as did the tree's underground root system. One such relationship involved root-dwelling microorganisms that can "fix" nitrogen and make it available to the host tree in usable forms. Through a metabolic process carried on by the microorganism, atmospheric nitrogen is transformed into nitrate and ammonium, both essential to plant growth. This relationship is manifested by the formation of nodules, or grapelike tissues, that appear on belowground roots. Peeling away epiphytic mats on mature red alder trees, which are known to be capable of fixing nitrogen, I exposed roots high above the forest floor that displayed well-developed nitrogen-fixing nodules.

Canopy roots of the big-leaf maple demonstrated yet another symbiotic association, called mycorrhizae, common to belowground roots. In this case, the vegetative parts of a fungus—threadlike filaments called hyphae—attach themselves to tree roots and, in a process not entirely understood, seem to enhance a root's capacity for taking up mineral nutrients from its surroundings. Some canopy roots were also mycorrhizal.

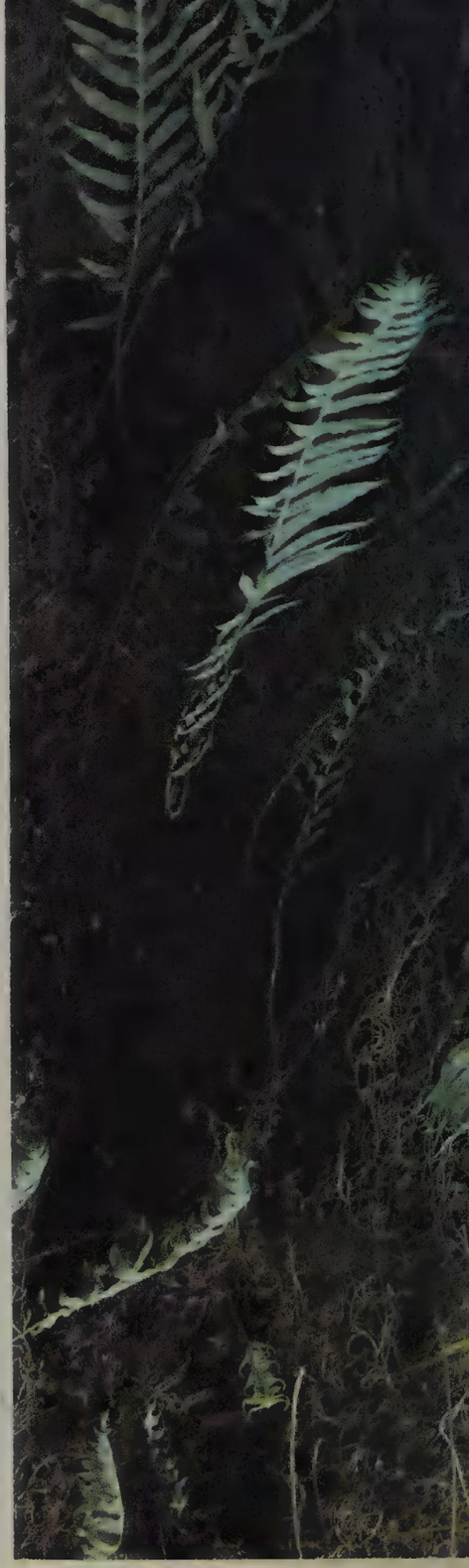
Extensive investigation has revealed that canopy roots were the same as belowground roots in their structure and anatomy, their capacity for forming symbiotic relationships, and their capacity for nutrient storage and transfer. If, by providing efficient nutrient transfer from epiphytes to host trees, canopy roots serve as a means of conserving nutrients within an ecosystem, then canopy rooting should occur on trees in geographically distant but environmentally similar ecosystems where high rainfall supports heavy loads of epiphytes.

In 1980, soon after research began in the temperate forest of Olympic Park, I journeyed to the cloud forests of Monteverde, Costa Rica, where epiphytes reach their greatest abundance and include the greatest number of species. Owned and administered by the Tropical Science Center in San José, the Monteverde Reserve protects approximately 10,000 acres

Douglas Gruenau

Roots that grow on branches and trunks are anatomically identical to their underground counterparts. Below: Nodules on a root emerging from a red alder trunk contain microorganisms that can transform atmospheric nitrogen into forms usable by the tree. Right: Shaggy mosses and tall ferns carpet the relatively sunny trunk of a big-leaf maple.

Doug Wechsler



of virgin, mountainside forests. Here along the Central Divide in the Tilaran Mountains, at an altitude of about 5,000 feet, cloud-bearing trade winds sweep the peaks and valleys throughout the year, and fog envelops the mountain crests in thick, huddling mists. The forest is characterized by wet soils and trees with divided trunks, gnarled limbs, and leathery leaves. On the wet, windward slopes of the uppermost forest, where trees are so stunted that the forests are commonly known as elfin woodland, epiphytes grow in profusion. In addition to mosses, liverworts, and epiphytic lichens, a huge variety of higher plants grows epiphytically, clothing the wind-sculpted limbs with green and brown sleeves of living plants and decaying matter.

Aloft in the cloud forest canopy, I was surrounded by erect shrubs, lianas, vines, bromeliads, flowering herbs, cyclanths ("Panama hat" palms), and fragile orchids. Lifting mats of epiphytes as I had done in temperate forests, I found canopy roots emerging from the branches of these tropical trees. Host trees belonged to a diverse assemblage of species: *Ocotea* (family Lauraceae), *Xylosma* (Flacourtiaceae), *Didymopanax* (Araliaceae), and *Weinmannia* (Cunoniaceae).

In 1981 I expanded my research to the South Pacific, exploring the mountainous cloud forest of Papua New Guinea and the temperate rain forests of New Zealand, both Old World counterparts of the forests I had originally investigated. Again and again I encountered the same phenomenon. Ten species of tropical trees growing on Mount Missim (elevation 9,700 feet) near the Wau Ecology Institute in Morobe Province, Papua New Guinea, had root systems high in the canopy. While I was tree hopping in the *Podocarpus* forests of Pureora National Park, North Island, New Zealand, my checklist of canopy-rooting trees expanded to include *Grisilinia lucide*, *Meterosideros umbellata*, and *Podocarpus totara*. The evidence was mounting: Canopy rooting is not restricted to a single phylogenetic line—to trees that share common ancestors and evolutionary development—or to any specific ecosystem. Rather, it seems to be a generalized response wherever epiphytic growth generates a source of water- and nutrient-holding organic matter.

Biologically, epiphytes are commensals: they and their host trees live in close association but do not harm one another. Nonetheless, epiphytes do affect the nutritional status of their host trees, in a wide range of interactions.

In all cases, epiphytes gain the benefits of support within the canopy: higher lev of sunlight than on the dark forest fl and avoidance of possible competit from ground-dwelling herbs and moss But if we look at the relation between e phytes and their hosts on a continuum kind of gradient of coexistence, what e phytes offer their hosts in return for s port ranges from the extreme of para ism to a more positive mutualism.

The best example of the negative eff that epiphytes can have upon their host illustrated by the relationship between various epiphytic orchids and their h trees and shrubs in tropical citrus plan tions. In this case, strands of fungi link to orchid roots burrow directly into host tree's vascular system, robbing it

ts nutritional resources. The condition, known as epiphytosis, can have a debilitating effect on the tree canopies, causing oss of vigor and eventual death.

An indirectly negative effect of epiphytes upon their hosts has been described by David Benzing, professor of biology at Oberlin College, in his investigation of Floridian Spanish moss and live oak trees. Benzing coined the term "nutritional pirates" to describe epiphytes that intercept and seize atmospheric nutrients before they become available to their hosts. Crown-dwelling epiphytes are more favorably positioned in the canopy and physiologically better equipped than their hosts to exploit the limited supply of nutrients borne in dust and rainfall. Ultimately this pirating can result in host decline: heavily infested oaks gradually put forth fewer and fewer leaves and grow more slowly.

Nutritional neutrality is typified by the moderate moss loads found on old-growth conifers in the Pacific Northwest. Epiphytic mosses inhabit the inner portion of the canopy where they exert minimal mechanical stress and where light levels are too low to support host tree foliage. Since the mosses grow only in moderation, their effect upon the availability of airborne nutrients is negligible.

An example of an indirectly positive effect of epiphytes on the nutritional conditions of their hosts has been documented in a study conducted by Larry Pike and George Carroll, professors of biology at the University of Oregon. In this study, researchers computed nitrogen input of nitrogen-fixing lichens on old-growth Douglas firs in the temperate forests of Oregon. They found that epiphytes indirectly add one to three pounds per acre per year of nitrogen to the ecosystem through fixation and subsequent decomposition. This contribution is described as indirectly beneficial to host trees since nutrients are made available to saplings, seedlings, and other understory vegetation as well.

Tropical rain forest epiphytes were also described as indirect nutritional contributors to the canopy ecosystem. Richard Forman, then a professor of biology at Rutgers University, estimated a nitrogen input of one to seven pounds per acre per

A temperate rain forest such as this one on Washington's Olympic Peninsula may support as much as 6,000 pounds (dry weight) of epiphytes per acre.
Harald Sund

year from lichens in a Colombian rain forest, as much nitrogen as enters the system through rainfall.

The epiphyte–host tree relationship shifts even further toward mutuality when canopy rooting is considered. In this instance, the host tree, which provides support for epiphytic growth, gains direct access to accumulations of organic matter and decomposed mineral elements *before* the nutrients become available to neighboring trees and vegetation. A mutually beneficial association seems to prevail, one in which a direct benefit is conferred upon the host tree through access to epiphytic nutrients and to the epiphytes through support and a suitable surface on which to grow and reproduce.

When I first contemplated epiphyte research, I encountered some skepticism in forestry and biology circles. Swinging through trees with special rock-climbing apparatus—fancy Tarzan gear as some called it—seemed too exotic or perhaps too much fun for serious scientific research. There were, after all, plenty of unsettled questions about plant life on the forest floor. Epiphytes were considered interesting from a strictly botanical point of view but were not thought to be particularly relevant to fundamental ecosystem-level processes such as nutrient cycling. Apparently this treetop community of epiphytes has a greater impact on canopy ecology than previously suspected.

Whether epiphytes and their host trees coevolved for the express purpose of mutual aid remains an open question. Their association, examined from a different perspective, could as easily be interpreted as competitive, with host trees "snatching back" the nutrients that otherwise would have been theirs had epiphytes not intercepted them first.

Whatever the driving force behind these interactions, canopy rooting tightens the link between two diverse elements in a complex forest by offering trees quick and direct access to nutrients. And epiphytes, the often tiny plants that seem to thrive on air alone, can play a significant part in the mechanism of nutrient conservation that makes forests so good at holding on to their limited supply of nutrients. □

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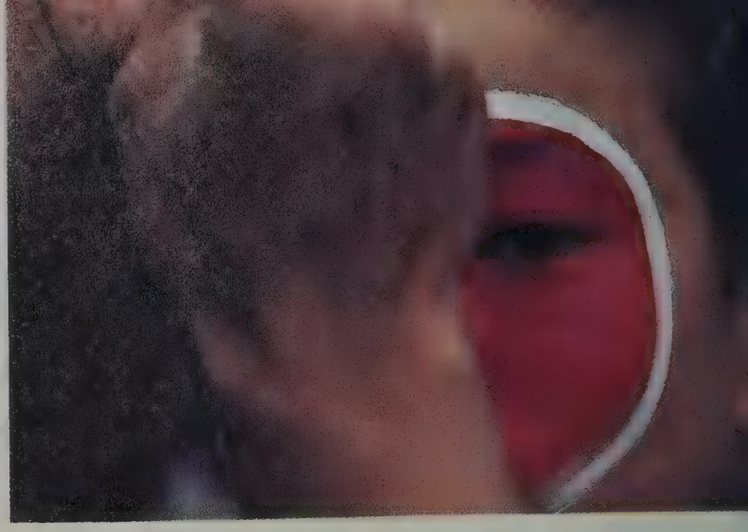
Welcome to the Year of the Ox!

For two weeks in January or February, all work comes to a halt as Chinese villagers celebrate the New Year

Photographs by Richard Gordon

A young actor from a semiprofessional opera company peeks out from behind a curtain. The troupe performs on outdoor stages in villages throughout Shaanxi Province.



Dressed as a pig, a boy on stilts, above, sets off giggles among this group of children, who recognize Pigsy, a character from Journey to the West, *one of the best-loved classics of Chinese literature. Pigsy is a former deity who intended to come to earth as a man, but he did something wrong and became a pig instead.*

A young boy, left, has a vivid red circle painted on his face, identifying him to all as the Monkey King, another character from Journey to the West. *The Monkey King possesses great magical powers and can see through the disguises of even the cleverest of demons and monsters.*

Villagers gather to watch the traditional Lion Dance, below. Inside each costume, two men coordinate their movements to manipulate the lion, as it blinks its eyes, snaps its mouth open and shut, and chases after a ball handled by a costumed man—all to the great amusement of the crowd.

A small boy stands behind the makeshift wall and gate of a newly constructed house. On the gateposts are New Year's couplets, which are put up by every family. Traditional couplets carry auspicious words about good weather, healthy children, and long life. The couplet here reads, "Sweet, sweet, sweet. Life is more and more sweet. Beautiful, beautiful, beautiful. The days are more and more beautiful."

As part of the two-week celebration, villagers build giant swings. This ancient custom has been mentioned in poetry and folktales for more than a thousand years, and stone rubbings of giant swings have been found that date back to the Han dynasty (202 B.C.–A.D. 220). During the festivities, unmarried men and women occasionally use the swings together, an activity considered very risqué.

Elaborately costumed young girls, above, are carried on poles in a procession through the streets of a village. Although they appear to be standing, the girls are strapped into small metal seats attached to the top of the pole. Their adult-size opera costumes include false legs and tiny (false) bound feet.

In the countryside, free movies are shown on outdoor screens about once a week. Opera, however, remains the favorite of elderly people, who tend to find the movies too daring. At righ a group waits patiently at the foot of an outdoor stage for an opera performance to begin.

A stilt dancer dressed as an elephant rider proceeds down a crowded street. The dancer may be impersonating one of the Eight Immortals, characters from a legend.

The custom of carrying young girls, about four to six years old, on poles in a parade is called kang zhuang *(literally, to shoulder a costumed person).*

band of stilt dancers, left, parades down a village street. close inspection of the dancers reveals several female personators in the group. Villagers feel that female personators have more freedom to flirt and dance in a anner that would not be appropriate for a woman.

The young girls, below, are riding in a decorated wagon being pulled by a tractor—part of a procession through the village streets. Sunglasses are a fashion fad in Shaanxi Province and are considered a stylish necessity for all special occasions—especially at New Year's, weddings, and performances.

Th

Rhesus monkey populations have declined seriously in Nepal and northern India. Many people no longer hold monkeys sacred, and some farmers trap them or drive them away. As a result, monkeys find refuge in public places, such as this Buddhist temple area in Kathmandu, Nepal.

Mark N. Boulton, Bruce Coleman Inc.

Rhesus Monkey's Fall from Grace

There is little place left in modern India for a sacred species

by Charles Southwick and M. Farooq Siddiqi

Admired and worshiped by some, cursed by others, rhesus monkeys fill a complicated ecological and cultural niche in India and Nepal. Orthodox Hindus consider monkeys sacred animals, to be revered and protected. This reverence stems partly from the role of the monkey god, Hanuman, in the *Ramayana*. In that classic Hindu epic, Sita, the beloved wife of Rama (the reincarnation of Lord Vishnu) is kidnapped by the forces of evil. Hanuman learns she is being held on the island of Lankah (modern Sri Lanka). But in order to get onto the island, a rescue party will have to cross the water. So Hanuman calls on the monkeys to gather in southern India and build a bridge. Hanuman, Rama, and their followers walk across that bridge, and after fierce fighting, rescue Sita. According to the legend, this represented the victory of good over evil. Today, many Hindu temples are dedicated to the monkey god.

Hanuman is usually depicted as a langur, a long-tailed monkey with a black face. But over the years, he has come to stand for all monkeys, including the rhesus, and all of them have enjoyed the privileges of deification to some extent. The rhesus ranges widely across India, but the populated regions with the greatest numbers of monkeys are often those connected in some way with the legend of Hanuman. Indeed, the religious associations that Indian people have with monkeys are the main reason these primates have been tolerated and protected.

In the Western world, the rhesus monkey has another sort of distinction, stemming from its role in biomedical and behavioral research. For more than fifty years, it has been a mainstay for scientists exploring ways to improve human health—mainly because of its physiological and immunological similarity to humans. The Rh factor in our blood was named after a similar protein found in the blood of the rhesus monkey. This primate was an experimental model for polio and hepatitis vaccines and has been used widely in almost every field of medical research. As a result of tests on pregnant rhesus monkeys, the tranquilizer thalidomide—which had been tested on mice, rats, and rabbits without incident and was being used with tragic consequences by pregnant women in Europe—was banned in the United States. All of this research required monkeys, and in the late 1950s, India was exporting more than 100,000 of them each year to Europe and the United States.

The rhesus thus had a contradictory sort of fame in the 1950s—worshiped on one side of the world, it was used for laboratory research and pharmaceutical testing on the other. But for those of us who wanted to study this fascinating primate and understand its place in nature, there was little to go on. We knew only a few facts—for example, that the rhesus was one of twelve macaque species and that it ranged over more than 5,000 miles of Asia, from Afghanistan in the west, across India and Nepal, to Bangladesh, Burma, and parts of Indochina. The most widely distributed primate, it once lived as far east as Hong Kong and is still found in the forests of Kowloon, a mainland peninsula of that city. Formerly, its northern limit was Peking. Now it is rare in China and has disappeared from many other parts of its eastern range. But the center of the rhesus monkey's population, and the place where it could be found in greatest numbers, was, and is, northern India.

We also knew that the rhesus was versatile ecologically, for it lived in cool Himalayan forests as high as 12,000 feet, in the hot lowlands of the Rajasthan Desert, and in the tropical mangrove swamps of the Sundarbans in Bengal. We knew that it had, at some point, developed a commensal relationship with human populations, receiving food and other benefits from that association. In India and elsewhere, the rhesus lived with people—in agricultural areas, villages, towns, temples, railway stations, and even major cities. In the crowded landscape of India, the rhesus seemed to be a survivor—the most intense human commensal of all primates.

But in the late 1950s no data were available on such basic matters as the animal's habitat distribution, population densities, group sizes, sex and age structures, breeding habits, or social organization. We knew very little about its food habits. As

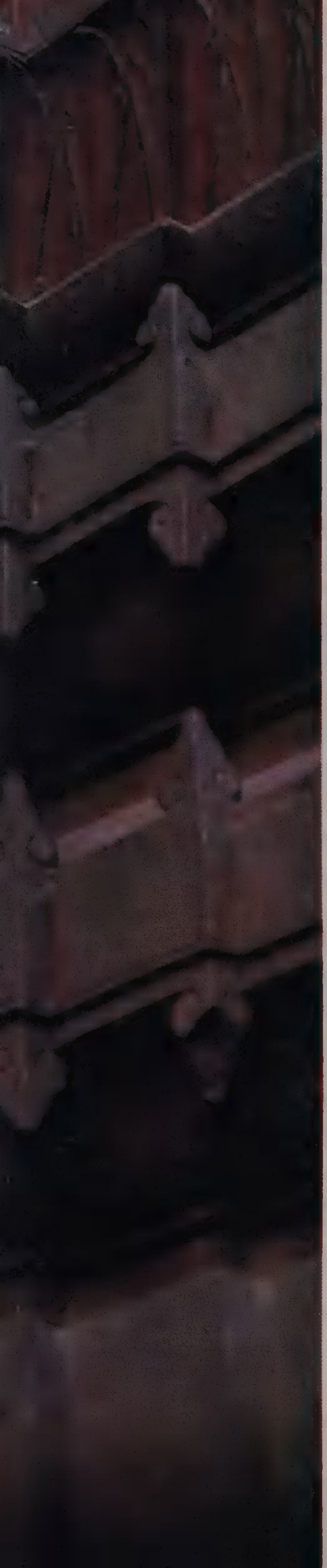
late as 1960, we didn't know whether rhesus monkeys actually had a mating season or bred throughout the year. In captivity, reproduction occurs throughout the year, but we soon learned in our fieldwork that rhesus have a definite breeding season from September to January.

There were other questions as well, perhaps even more pressing ones, raised by the human relationship to monkeys. How many rhesus monkeys actually lived in northern India? What were their population trends? How were the populations organized, ecologically and socially? What did contemporary citizens of India think of the export of rhesus? And could the monkey populations continue to sustain modern science with a harvest of 100,000 or more individuals per year?

When we began our study in 1959, we planned a year of fieldwork. Soon after our first field season, we realized that we needed three to four years. Now, as we complete our twenty-fifth year of fieldwork, many topics still remain to be investigated. But one alarming fact has emerged: the rhesus monkey population of northern India has seriously declined since 1959. Some people may attribute the loss to the export of rhesus monkeys. But we learned early in our studies that the exploitation of the monkeys was only part of the circumstances affecting them. Their situation in India is a complicated and changing one, and to understand it, we had to understand something of the changing identity of India herself.

Our first task was to find out how many monkeys there were. When we began our studies, government officials, scientists, and naturalists felt the rhesus population numbered in the millions—that it was so large that the levels of export in the 1950s and 1960s were not having any impact. Jim Corbett, one of India's respected naturalists, estimated the monkey population of Uttar Pradesh, the north-central province occupying much of the Gangetic basin, at "not less than ten million." Some estimates ran as high as twenty million.

In 1959, we began three kinds of studies. The first was an extensive population survey throughout northern India, the second a more intensive study of one popula-



Many rhesus monkeys in the central Indian city of Varanasi (Benares) live around Durga Temple, known locally as the monkey temple. People feed rhesus as a tribute to Hanuman, the monkey god, who symbolizes the triumph of good over evil.
Rajesh Bedi

tion in Aligarh District, eighty miles southeast of New Delhi, and the third a behavioral study of groups of rhesus monkeys living near monkey temples in the city of Aligarh.

How does one count monkeys in the diverse landscape of northern India? We began with seven different types of field surveys, designed to cover all habitats systematically. We used all available means of transportation—automobiles, bicycles, trains, and most often, our own feet—to crisscross the landscape as carefully as possible. In our first nine months, we logged more than 18,000 miles, talking with local people and thoroughly inspecting 280 villages, 30 towns, and 15 cities in northern India. We censused more than 200 Hindu temples and more than 440 railroad stations, and we combed 6,400 acres of forestland in the Himalayan foothills.

From these efforts we learned that the popular notion of how many monkeys lived in India was greatly exaggerated. Our survey indicated that rhesus monkeys in Uttar Pradesh numbered 800,000 to a million, or about 10 percent of what we had been told. And we further estimated that 88 percent of this population lived near human settlements—villages, towns, cities, roadsides, canal banks, or temples. Only 12 percent lived in the forested areas. Almost everywhere we went, we found that local people overestimated the number of monkeys living near them. Fifty monkeys, by virtue of their visibility, boldness, and activity, could create the impression of several hundred.

Another factor that impressed us was the patchiness of rhesus distribution. In some areas, like the sacred towns of Ayodhya and Faizabad, there were many groups, sometimes as many as seventeen in just five miles along the road. In other places we could ride or walk for a hundred miles and find only one or two groups, sometimes none. "There used to be monkeys here," local people told us, "but not anymore."

But what most shocked us in those initial forays was the distorted age range of the monkeys. There were conspicuous shortages in one age group—monkeys one to two and one-half years old. Juveniles in this category, past weaning but sexually immature, should make up at least 25 percent of a numerically stable population. Instead, they were only 5 percent of the total population. Monkeys in this age group, particularly those about eighteen months old, were in greatest demand for research. This meant that trapping for export was making a serious dent in the population. Where monkeys were less likely to be trapped—in temples and protected forests—the population's age distribution was normal.

We also found that Indian villagers were deeply ambivalent about the rhesus monkey. Although they still professed to respect monkeys for traditional reasons, they considered the rhesus a pest—particularly in agricultural areas where the monkeys often pilfered crops. Many villagers asked us to trap and take the monkeys away. Unwilling to kill them, people nonetheless tried to drive them off or break up groups. The monkey's status in India had obviously changed. When we explored the Terai, that band of forest running along the Himalayan foothills, we saw another sign of the times. India's greatest wildlife areas, the forests of the Terai were being invaded to make room for agriculture and grazing land. This development inevitably had to affect rhesus monkeys dependent on forest habitat.

What we were seeing, of course, were the beginnings of India's change to a more modern, industrialized, and growth-oriented society. During our twenty-five years in India, the human population doubled from fewer than 350 million people to more than 700 million. Each year we saw increasing evidence of conflict between traditional beliefs and the realities of survival. We were particularly struck by this in small villages, where local people grew their own crops and were entirely dependent on local food production.

Rhesus monkeys consume virtually all vegetable foods that humans eat. They raid crops and rob food stores at every opportunity. They love mangoes, papayas, bananas, sugar cane, rice, grams (leguminous beans, somewhat like soybeans), peanuts, wheat, millet, and most vegetables.

A triumvirate of monkeys holds court on a rooftop in Agra. The sign is an advertisement for a writing pen. Urban monkey populations in northern India have declined less than village populations, mainly because they don't threaten people's livelihoods, and thus are tolerated. But even in rural settings, some people have returned to a more traditional respect for the rhesus. At right, a knife peddler stops to feed a roadside group in Tughlaqabad.

Doranne Jacobson

With food supplies a constant problem, the average villager simply cannot afford to have a group of monkeys ready to pounce on his crops. Small children and elderly people are regularly employed as *chowkidors*, or guards, to protect the crops against the depredations of monkeys. Traditional Hindus believe that monkeys have a "right" to whatever food they need, but many of the contemporary villagers we spoke to are more pragmatic. They still believe in the legends of the *Ramayana*, but they no longer accept the idea that they can do nothing about poverty and hunger, that they are powerless to act against the monkeys. Without rejecting their religion, they are modifying some of its teachings in practice. In the last two or three years, there has been a noticeable resurgence of classical Hinduism in India, and more people are once again feeding monkeys along roadsides and in temples and parks.

Another major influence upon the rhesus monkey has been habitat destruction of the sort we witnessed in the Terai. Since the early 1950s more than seven million acres of Indian forests have been cut. Much of this land has been taken over by agribusiness, and small farmers have had to sell to larger landholders. Now many farms are fifty or a hundred acres. Corporate managers often show little tolerance for rhesus monkeys; they certainly don't consider them gods, and the traditions of Hinduism are less of a constraint for them.

Reforestation efforts are under way in India, but most plantings are of single-species stands, especially eucalyptus species, which are relatively worthless as wildlife habitat in comparison with the rich mixed-species forests being cut. Initially, this practice drove rhesus monkeys to the roadsides, where some fringes of the old forest still remained and where, outside of villages and fields, they were less likely to be bothered by people. More recently, even these marginal areas have been cut for lumber and firewood, and many roadside stands of fine banyan, pipal, neem, jamun, and mango trees are gone.

During our first year of fieldwork, long before we had a clear picture of these other factors, but armed with what we felt was a fairly accurate idea of rhesus population trends, we predicted the number of rhesus monkeys in India was declining. Since 1960 we've had the opportunity to test these predictions several times, first after five years, in 1964 and 1965, and again after twenty years, in 1979 and 1980. We retraced our early work over a broad expanse of northern India as precisely as possible, using the same field methods, the same routes and study areas, and basically the same field teams. Unfortunately, the data supported our early predictions. There has been a serious decline with relatively few local exceptions.

Between our first and second surveys, roadside groups of monkeys in northern India declined 26 percent; by 1980, that decline deepened to 77 percent. In other words, three-fourths of the rhesus living in roadside habitats disappeared over the twenty years.

Along canal banks, which are less disturbed by human traffic and which often have ideal habitat, a similar situation prevailed. When we repeated a survey of more than 180 miles in this habitat, we found that 76 percent of the groups of rhesus monkeys had disappeared.

In village habitats, the loss was alarming. In our 1959–60 study, 44 of the 280 villages we visited had resident rhesus monkey groups. Twenty years later, only 5 of those villages had monkeys. To make sure that the missing groups hadn't simply moved to other villages, we surveyed an additional 245 villages and found no rhesus in them. Total numbers of village rhesus had declined 94 percent.

Our intensive study of monkeys in Aligarh District gave us a more detailed picture of what was happening in rural areas. Aligarh is typical agricultural land of the western Gangetic basin. It is flat, intensely cultivated with wheat, gram, sugar cane, millet, and other crops; moderately well-watered with canals from the Ganga River; and densely populated by approximately 500 people per square kilometer in the rural areas. In this district, we selected seventeen groups of rhesus monkeys in typical habitats, including temples. The groups varied in size from six to forty-nine monkeys, with an average of twenty per group. A typical group consisted of four adult males, eight females, six infants under one year of age, and two juveniles aged one to three. These groups occupied roadsides, villages, schoolyards, canal banks, and forest patches. With continued support from the National Institutes of Health, we have censused these groups three times annually: in March and April, just before the birth season, to obtain the

Rod Johnson

lowest population count of the year; in July and August, just after the birth season, to record all births and the highest population of the year; and in October and November, just after the monsoon, to get a record of early infant mortality and monsoon deaths.

In 1962, after three years of moderate increase, the population began an erratic decline, dropping from a high of 403 monkeys in twenty-two groups to a low of 163 monkeys in only ten groups by March of 1970. Twelve of twenty-two groups disappeared entirely. In some, every individual had been trapped; other groups had been broken up or declined slowly by attrition. There were no significant animal predators—but both dogs and people harassed the monkeys. We saw one instance in a canal bank group where a dog snatched and killed a young infant. Boys and men often threw sticks and stones at monkeys and occasionally shot them with powerful slings.

The picture was somewhat better in towns. We defined towns as places with more than 2,000 inhabitants, with markets, temples, parks, and other public areas. Of thirty towns that we surveyed, twenty-one had rhesus groups in the early study, and sixteen had them twenty years later—a decline of only 24 percent.

Why would rhesus in towns lose only 24 percent and those in villages so much more? In villages, the monkeys are a threat to survival. But in towns, most people are not farmers. They buy food at the market, and rhesus monkeys in the town's parks or shrines are not an immediate threat to them. Townspeople enjoy the monkeys—parents and grandparents often bring their children to feed them. Sometimes it's a religious ritual, but often it is like going to an open zoo whose borders correspond roughly to the town's public areas. The ever adaptable rhesus scrounges and begs, and people supply the food. In these settings, the rhesus is a little like the pigeon in big cities, except rhesus monkeys are much more animated. They are equally at home on the ground, in trees, and all over buildings. They love to dive and swim in ponds or lakes. They chase, beg, quarrel, play, and occasionally cause a minor furor when one of them bites somebody. Rhesus generally inspire that ambivalent mix of affection and distaste one feels for an endearing but mischievous pest.

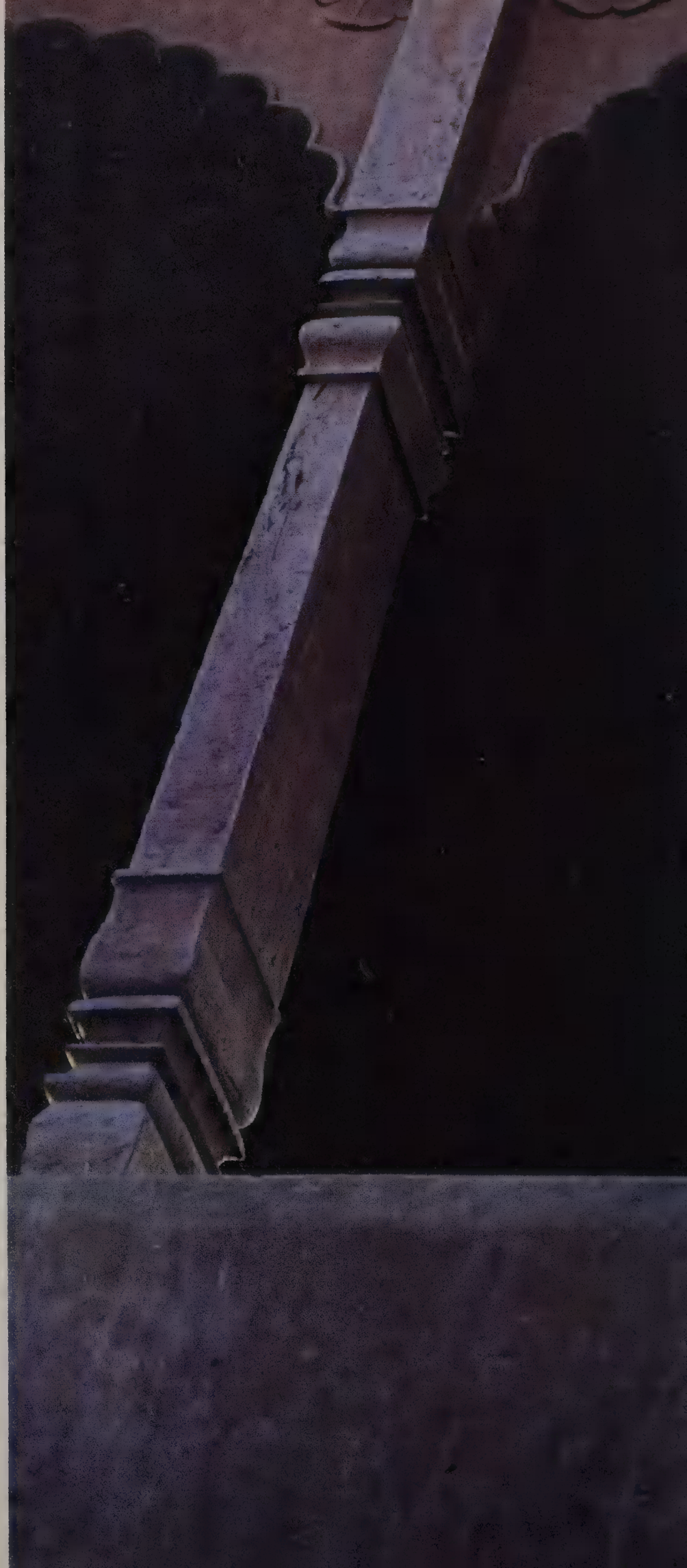
Another habitat we have tracked for rhesus populations over these years has been the forests of the Terai. Our figures there are less precise, but those we have from Corbett National Park showed rhesus populations to be stable, with less than one group (0.7) per square mile. This stability is encouraging, but Corbett is one of only a few national parks inhabited by the rhesus monkey. Most of India's forests are not so well protected.

When we put all our figures together, we estimate that since 1960, the rhesus population of northern India has declined between 80 and 90 percent. Based upon our initial population estimates from 1960, we now estimate the population of Uttar Pradesh to be 80,000 to 100,000 monkeys. We also conclude that the rhesus population in all of India is now on the order of 160,000 to 200,000 monkeys—certainly a dramatic difference from the 5 to 10 million, or even 20 million, animals thought to inhabit Uttar Pradesh alone in the 1950s.

In the late 1970s, the Indian government became concerned about its dwindling primate populations. In April 1978, the government placed a total ban on rhesus export. Export had declined significantly to only 18,000 rhesus in 1977–78, but officials felt even this was too serious a loss in concert with other ecological and social forces acting against the monkeys of India. Some trapping is still permitted within India to obtain monkeys for biomedical research, but trapping for export was stopped in 1978.

A monkey family takes time to groom and nap in Varanasi. Where monkeys are protected, they show high birthrates—one study in Aligarh District recorded a rate of 90.3 percent—and they can increase their numbers rapidly.

Rajesh Bedi



In 1977, just before the export ban, the government launched a nationwide survey of primate populations—a major mobilization of scientific expertise covering not only rhesus monkeys but also langurs, bonnet macaques, lion-tailed macaques, and Hoolock gibbons.

The National Primate Survey of India, under the leadership of K.K. Tuvari, R.P. Mubherjee, and G.U. Kurup, took twenty-one professional scientists and more than thirty-five fieldworkers five years to finish. Field teams undertook one of the most thorough national coverages of primate populations ever attempted—they surveyed virtually all of India's twenty-five provinces. They also found that Uttar Pradesh had the greatest concentration of rhesus in India. More extensive and detailed than our own, the national survey estimated that the rhesus population of India was only 183,000 individuals in 1983. One of the world's greatest nonhuman primate populations was now a fraction of its former self.

In this discouraging situation, there are some encouraging exceptions. One of the most striking to us was the case of a small group of monkeys living in a grove of trees surrounding a rural schoolyard in Aligarh District. This place, known as Chhatarido-Raha, was rigorously protected by the schoolmaster and two elderly guards. They permitted no trapping or harassment of the monkeys, though the monkeys were on their own once they wandered out of the schoolyard compound and its sheltering trees. None of the other groups in our Aligarh sample had even this degree of protection. During the eight years from 1962 to 1970, the Chhatari rhesus population actually increased from forty-nine to seventy-four individuals. To us, this was a dramatic example of how important the human factor was. The Chhatari habitat was not any better than many other sites in Aligarh District; in fact, it was sparser in cover and space. The difference was the protection afforded by local people.

Throughout most of the 1970s, the Chhatari population continued to thrive, while the remainder of the Aligarh population declined. By the summer of 1978, Chhatari reached a population of 149

People and monkeys mingle on the steps of a Hindu temple. In Indian cities, rhesus are often ubiquitous, much like pigeons in New York or London, and they inspire the same mixture of affection and distaste.

Thomas Richie

monkeys, whereas the rest of Aligarh District had only 87. Throughout these years of study, the Chhatari monkeys maintained a remarkably high (90.3 percent) birthrate, and a low infant-mortality rate. Juvenile loss was moderate (31.5 percent) and adult mortality was also low (only 12.5 percent per year).

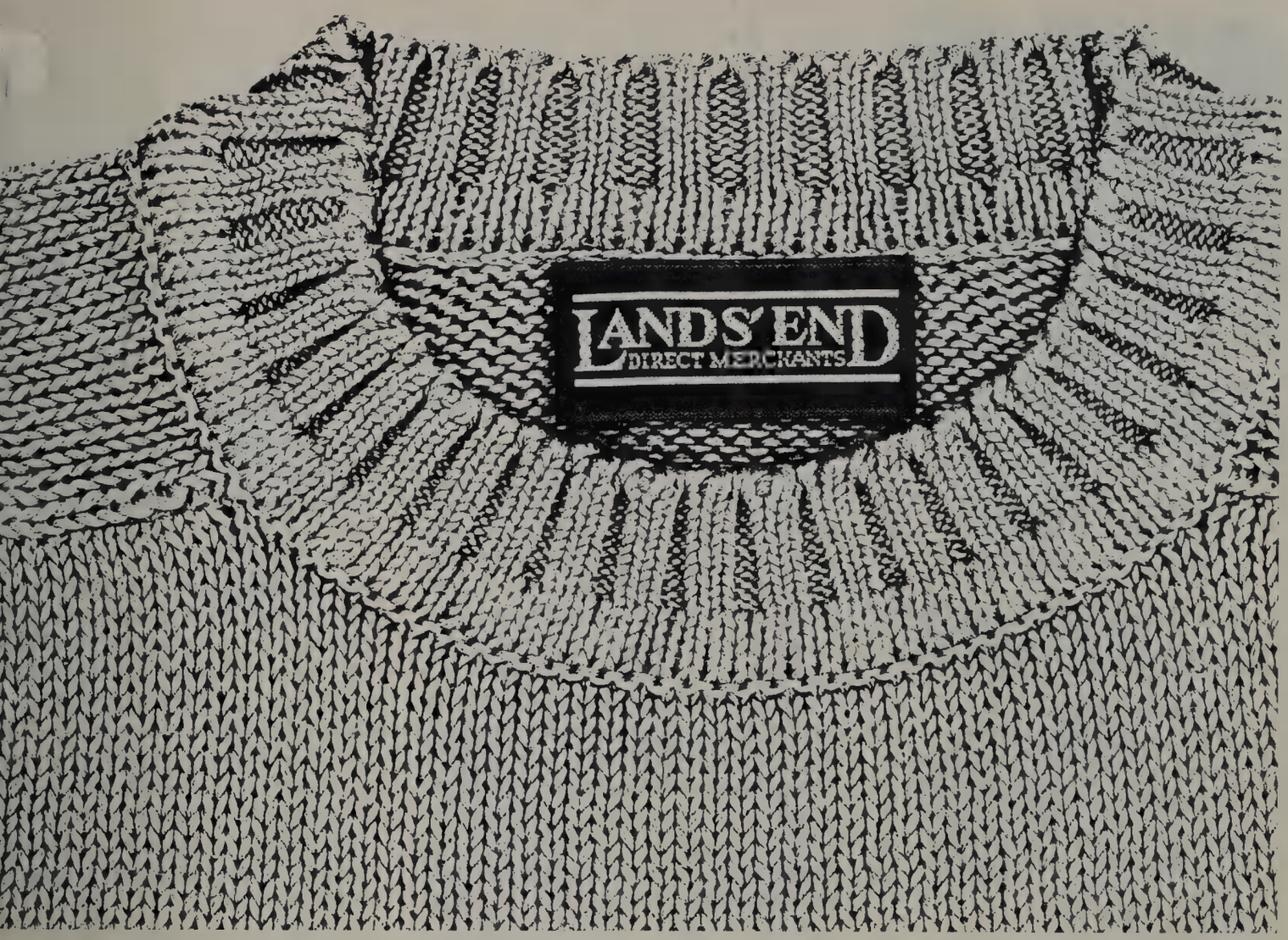
The unprotected rhesus monkeys of Aligarh had a lower birthrate (76 percent) and higher mortality rates in all age classes (18 percent in infants, 54 percent in juveniles, and 17 percent in adults). The impact of human attitudes and behavior on a nonhuman primate population was unmistakable. Rod Johnson of the University of Colorado has been doing a detailed behavioral study of rhesus mother–infant relationships in an attempt to learn more about the secret of Chhatari's success.

There are other locations in northern India where the local rhesus population is thriving. In the archeological site of Tughlaqabad on the southern outskirts of New Delhi, Iqbal Malik has studied a population of rhesus monkeys that has increased markedly in recent years. This is a large protected area of two square miles, surrounding the ruins of a fourteenth-century city, and it also contains several hundred acres of young forest plantation. With complete protection and an improving habitat, the Tughlaqabad groups have increased from two to five and their total population has more than doubled, from 120 to 286, in four years.

We have also censused rhesus groups in Banda District of southern Uttar Pradesh, where a local population on a sacred hill increased from five groups with 109 monkeys in 1960 to eleven groups totaling 267 monkeys in 1980. P.K. Seth, an anthropologist at the University of Delhi, found nine other rhesus groups throughout Rajasthan, Haryana, and western Uttar Pradesh that increased 66 percent between 1975 and 1980, with a total population change from 400 individuals in 1975 to 665 by 1980.

Can these small increases constitute a major change in the status of rhesus monkeys in contemporary India? The evidence is secure that rhesus monkeys can increase rapidly in number when protected and supplied with adequate habitat. Since increased numbers of monkeys in some areas may create agricultural problems, one solution would be to relocate subgroups from very large groups to unoccupied habitats. We have recently undertaken a pilot study of this type by relocating twenty monkeys from a large group of more than a hundred that were doing serious damage in a mango grove. We moved them to an unoccupied canal bank area in September 1983, and so far these monkeys are doing well. We had to feed them for several months to keep them in their new location, but this supplemental feeding has now been stopped and they seem fully adjusted to their new home range. They are producing well.

Fortunately, India's agricultural outp has increased greatly throughout t 1970s, and we hope that this will mitiga some of the conflict between primates a people, between India's critical need food and the desire of her people to c serve their rich store of wildlife, amo which primates have such an importa role. We do not believe the rhesus monk population of India can ever be what once was—and certainly not what peo imagined it to be—but we have reason hope that it is now recovering from ma years of decline.



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The Hall That Mead Bu

The Margaret Mead Hall of Pacific Peoples, a new permanent exhibition hall, opened on December 14 at the American Museum of Natural History. In 1971, Mead herself summed up the importance of creating an exhibition for the Museum: "Anthropologists do collect as part of their work, looking ahead to a time when they will make an exhibition. This is a very different matter from organizing an exhibit from a random assembly of spears, shields, baskets, and bowls. . . .When you make your own collection, you know why you chose each piece, just how it was used, and often who made it."

The hall presents the cultures of the peoples of the Pacific islands. Some 1,500 artifacts illustrate such cultural activities as the puppet theater of Bali, the kava drinking ceremony of the Samoan people, and the Trobriand Islanders' kula exchange system, which uses shells and necklaces to reinforce trade relationships. Other displays show the kinds and uses money; the use of coconuts and betel n the types and uses of weapons; the cheology, ethnology, and physical thropology of the Pacific; and the effe of contact with Western culture.

The earliest piece displayed in the is an archaic kris from Java. Later a facts are post-World War II. Some pieces displayed in the hall were collec by Mead. Among the more unusual a facts are a Maori feast bowl used to se dog flesh; a full-sized, intricately car Maori storehouse; a navigation chart u by the people of Micronesia; and a twe foot-high cast of an Easter Island hea

The hall also features an entire case voted to the art of the Sepik River Ba Artifacts range from the naturali (birds, crocodiles) to the highly abstr (spirit masks). The works are known their bold, colorful forms.

Mead wrote that the hall should ref

At the American Museum

New Magazine for Children

Faces, a new magazine for children eight to fourteen years old, is being published in cooperation with the American Museum of Natural History. It will contain articles, games, puzzles, and stories about world cultures, anthropology, and archeology.

Each issue will have a special theme; among them will be dragons, Indian myths and legends, keeping warm, and African gold.

Faces is published by Cobblestone Publishing in cooperation with the Museum. Subscriptions are $13.95 for members of the Museum, $16.50 for nonmembers. To subscribe, please make your check payable to Cobblestone Publishing and send it to: *Faces* Magazine, 20 Grove Street, Peterborough, NH 03458. If the subscription is a gift, indicate whether you want a gift card to be sent in your name.

Return of the Osprey

The Membership Office is presenting *Return of the Osprey*, a film by Michael Male and Judy Fieth. Their close-up view of several osprey families on Long Island nesting, raising young, hunting, and courting will be shown on Thursday, February 14, at 7:30 P.M. in the Auditorium; it free and open only to members. For tick information call (212) 873-1327.

Black History Month

February is Black History Month at t Museum, and a number of events ha been planned to celebrate contributio by blacks to American and world cultur

People Center Events: Every weeken the Leonhardt People Center will featu free lecture-demonstrations, music, a dance from 1:00 to 4:30 P.M. Programs i clude a demonstration of African a American weaving styles and an explor tion of black music.

Kaufmann Theater: On Sunday, Fe ruary 10, there will be two performanc of African festival dances at 2:00 and 4: P.M. On Saturday, February 23, the Inn Circle All-Stars will present a conce tribute to Sarah Vaughan. Both progra are free, but tickets to each must picked up at the first-floor informati desk starting at 12:15 the day of the pe formance. For more information c (212) 873-1300, ext. 514.

The Black West

One-fourth of all cowpunchers w

e blue of the sea, the bright sky, the far as and sunlit shores" of the Pacific re-n. Working with Eugene B. Bergmann, igner in the Museum's Department of nibition and Graphics, she approved basic plans for a hall that achieves this ct.

The hall is designed so that color-coded pet islands appear to float on a sea of e terrazzo tile. Each zone focuses on of six major cultural areas of the Pa-c—Australia, Indonesia, the Philip-es, Melanesia, Micronesia, and Polyne-—and is set off by the colors of the peting and display cases.

The life styles of four regions are de-ted by models, each approximately ee feet by six feet, and built on a scale three-eighths of an inch to one foot. ey illustrate in detail a Samoan village, temple dancers of Bali, the aboriginal ial rites of the snake clan in the rramunga group of Central Australia, and a Manus (Admiralty Islands) village.

The Manus model is the only remaining three-dimensional document of the life style of a Manus water-village. Constructed in 1932, a few years after Mead completed her first collection in the Admiralty Islands, the model depicts a village built on stilts in a lagoon. A typical Manus village consisted of seventy-five huts, and inhabitants used dugout canoes to travel from home to home. The people of this region abandoned this life style after they fell under the influence of other cultures, and their descendants now live on land.

While planning the new hall, Mead wrote: "Not only will our children see these things. The descendants of Hawaiians, Trobrianders, Balinese, and Australians will come to America as students, and here in the Museum they will find the stone tools and weapons, the fragile ornaments and precious objects made by their ancestors cared for and safe."

rove cattle up the Chisholm Trail were ack, thousands of blacks joined Indian ibes, and 20 percent of the U.S. Cavalry ere black. *The Black West: Black Cow-oys and Indians*, a lecture and dramatic terpretation to be presented on Wednes-ay, February 13, at 7:00 P.M. in the Audi-rium, will reveal many other little-nown facts about the West. This free rogram is made possible in part by a gift om the Evelyn Sharp Foundation.

lonkey of the Clouds

The Peruvian yellow-tailed woolly mon-ey, one of the rarest monkeys in the orld, lives in a small area of the Peruvian ndes. It had been presumed extinct for early fifty years until one was spotted in 974. On Sunday, February 14, at 11:00 M., 1:30 and 3:30 P.M., a film and slide rogram about this elusive monkey will be resented in the Kaufmann Theater. lembers will also learn about world-wide nservation efforts to save endangered rimates. Presented with scientists from e World Wildlife Fund, the program is ee and open only to members. For ticket formation call the Membership Office (212) 873-1327.

arwin's Ark

Philip Appleman will read selections from his new book of poetry, *Darwin's Ark*, inspired by Charles Darwin's *Origin of Species*, in the Hall of Ocean Life on Tuesday, February 5, at 7:30 P.M. The free program is open only to members; contact the Membership Office at (212) 873-1327 for ticket information.

1985 Spring Lecture Series

The Museum's adult lecture series will begin in February. This year's special lectures include Variety of Jewry: An Ethnography; Alaska: Giant of the North; Wildflowers; Islamic Arts and Sciences; World Music Festival; Landscape for Travelers; Origami; Foraging for Dinner; Animal Drawing; Insects; Anthropology Through Film; Travel Photography; and Saturday Field Walks in Botany. For information about lecture schedules and prices, please contact the Education Department at 873-1300.

Planetarium Events

The Violent Universe is the Sky Show at the Hayden Planetarium. Narrated by Vincent Price, this show delves into the forces that shape our universe. Topics covered include black holes, exploding galaxies, and the big-bang theory. For information about this and other Planetarium programs call (212) 873-8828.

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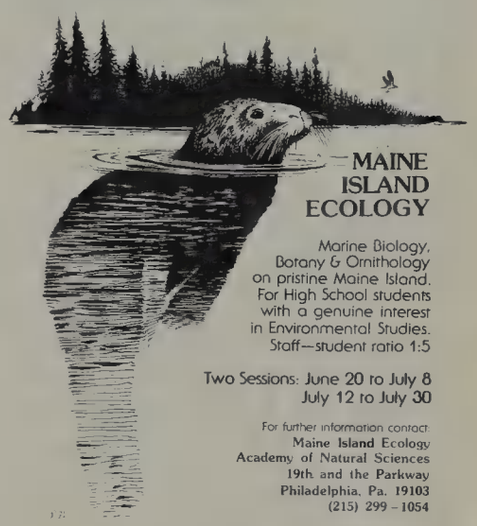
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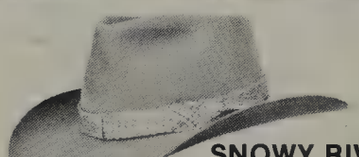
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Hill Tribes of Thailand

by Alain Y. Dessaint

PEOPLES OF THE GOLDEN TRIANGLE: SIX TRIBES IN THAILAND, by Paul and Elaine Lewis. *Thames and Hudson, $29.95; 300 pp., illus.* HIGHLANDERS OF THAILAND, edited by John McKinnon and Wanat Bhruksasri. *Oxford University Press, $49.50; 358 pp., illus.*

The dozens of ethnic groups that inhabit the fragmented highlands of Thailand and neighboring Burma, Laos, and China have been much in the news over the past decade. International issues, from political insurgency to opium growing, brought them to public attention; war forced some to resettle in the United States and elsewhere. Most of these cultures, visibly distinguished from each other by colorful tribal costumes, are agricultural, and some are still nomadic, depending upon slash-and-burn cultivation.

But the last ten years have seen imme changes. New roads that crisscross no ern Thailand have ended the physical a psychological isolation of all but the m remote villages. Where once it took ho or even days of walking to arrive at a lage from the nearest road, one can n ride four-wheel-drive pickup trucks within a few minutes of most highland lages, at least in the dry season. But ru roads have brought mixed blessings. the one hand, there is easier access to m ical facilities, markets, and schools; on other, there is entanglement in a consu society, loss of faith in traditional cur methods, and children brought up lea ing a new language and a new culture. creasing numbers of hill tribesmen n have radios (there are now daily bro casts in each of the major highland l guages), tape recorders, and even Ja

Lahu She Leh village

Hansjörg Mayer, *Peoples of the Golden Tri*

NE

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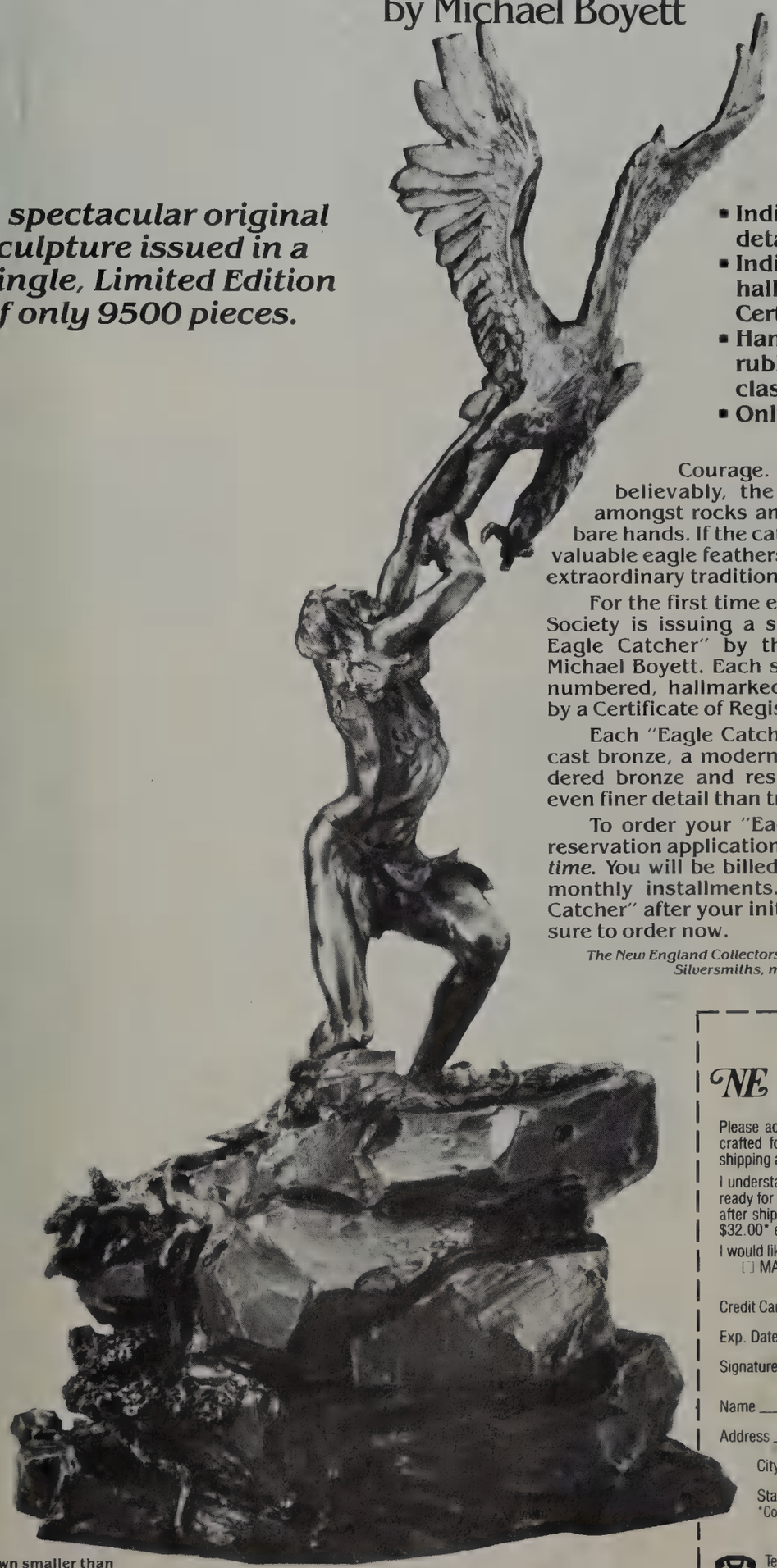

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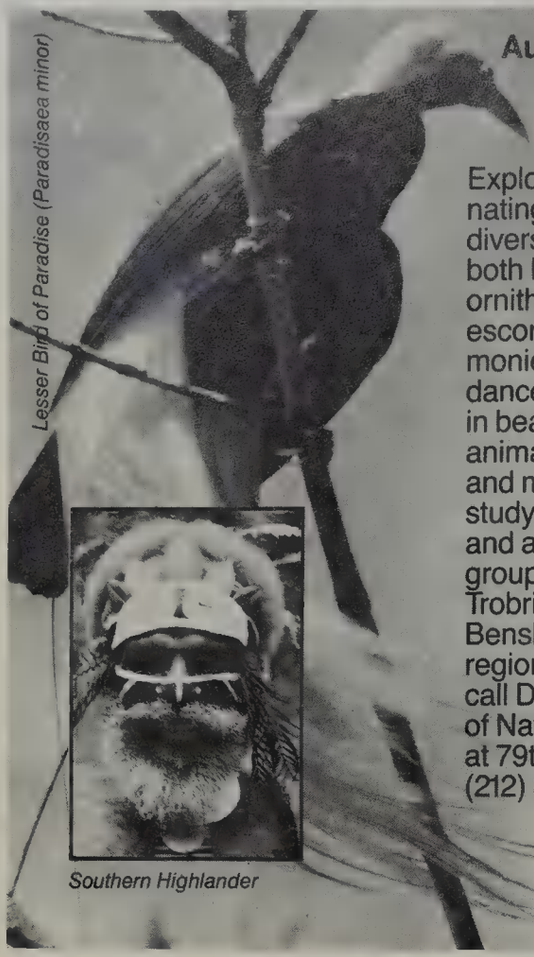

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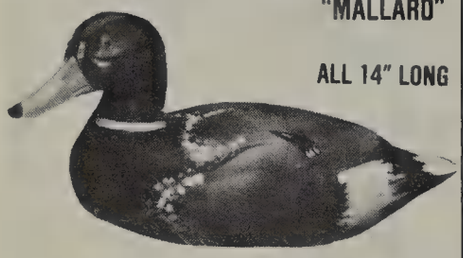

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nese motorcycles and pickup truc
Today, Thai songs and rock music vie wi
the roar of motor vehicles to break the t
ditional serenity of the mountain villag

A spate of books have been recen
published about the highland people
northern Thailand, but the two books u
der review, one academic and the oth
aimed at a general audience, are the be
of the lot.

Peoples of the Golden Triangle conce
trates on the traditional cultures of t
Hmong (Meo), Mien (Yao), Karen, a
three Yi groups: the Akha (about who
Paul Lewis has also published a four-v
ume monograph), Lahu, and Lisu. This
the most attractive and best written of t
recent books. It manages to combine t
usefulness of a culture summary with t
liveliness of personal vignettes and pa
after page of exquisite color photograph

Paul and Elaine Lewis, both mission
ies with an anthropological bent, ha
spent more than three decades living wi
and studying the hill tribes of Thaila
and Burma. They have organized th
book in terms of such cultural themes
harmony, independence, continuity, a
family primacy: the Karen desire for ha
mony with their environment, the supe
natural, their neighbors, and one anoth
the Hmong desire for economic, soci
and religious independence; the Mien d
sire for propriety; the Lahu desire f
blessings such as health, wealth, and fre
dom from worry; the Akha desire for co
tinuity with their ancestors and histor
and the Lisu desire for primacy of th
family, clan, or village. One could quibb
that all six goals are held by each of t
groups discussed, but as long as the read
recognizes the obvious oversimplificatio
this approach does much to integrate t

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book while differentiating among six si
lar yet distinct ethnic groups.

But the really striking characteristic
this book are its photographs and des
(for which Hansjörg Mayer deserves
ognition). Even those with no interest
the subject matter will admire the arti
quality of the photographs of village
and material culture: embroidery, sil
jewelry, ivory ear ornaments, wood, h
and-silver opium pipes, musical inst
ments, basketry, batik, agricultural im
ments, houses, hunting weapons,
traps. This is the next best thing to visit
a museum!

In fact, the enchantment of the c
and warmth of these photos is at odds w
the real world of northern Thailand.
the authors remark, "The picture
peaceful tribal people living in the prist
beauty of cool, quiet hills" must be
anced by the reality of "staving off h
ger, caring for sick children, being vict
ized because of one's illiteracy, be
denied citizenship, or being gawked at
tourists and laughed at by townspeopl

The romantic may lament the pass
of traditional cultures, but who can d
that some individual highlanders are
ter off because they went to sch
learned to read and write, even earne
college degree, or are able to buy and
in a free market? Increasing numbers

Silver bracelets worn primarily by Lah and Akha men

ghlanders are attending Thai schools
d universities, and many surprise me by
e sincerity with which they want to use
eir learning for the benefit of their peo-
e, not just for themselves. Some hill
besmen work as guides for tour oper-
ors in the city of Chiang Mai, learning
nglish in the process since most of their
ents are American or European. Others
ve found employment with the Border
trol Police. Some 50,000 highlanders,
ostly Meo and Yao, have been resettled
the United States, Europe, Canada,
ustralia, and South America. Many
ore have spent time in these countries
udying, working, or simply visiting.

Highlanders of Thailand devotes more
ace to these matters but is primarily for
e specialist. The contributors have all
en associated with the Tribal Research
entre in Chiang Mai, which, as W.R.
eddes discusses in his introduction, has
elf been accused of being an outside in-
gator of change. Some of the essays are
oad introductions to the various high-
nd groups (including not only the six
entioned above but also the northern
nai, highland Chinese, and several small-
groups); but most chapters address nar-
wer concerns, such as shamanism, sex
les, and the traditional treatment of
ath. This is the best of the academic
oks on the subject, for both its breadth

Peoples of the Golden Triangle

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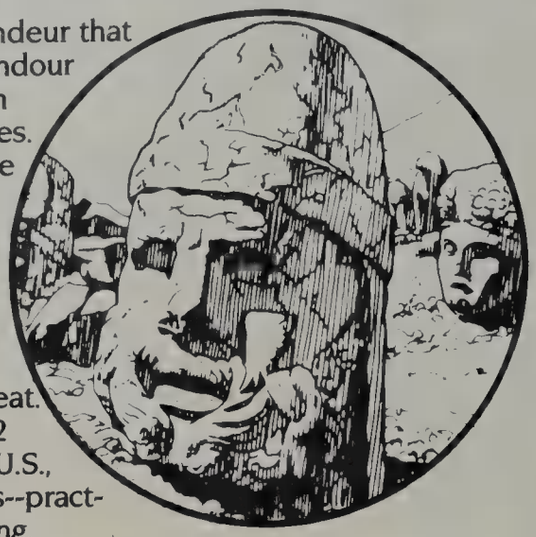

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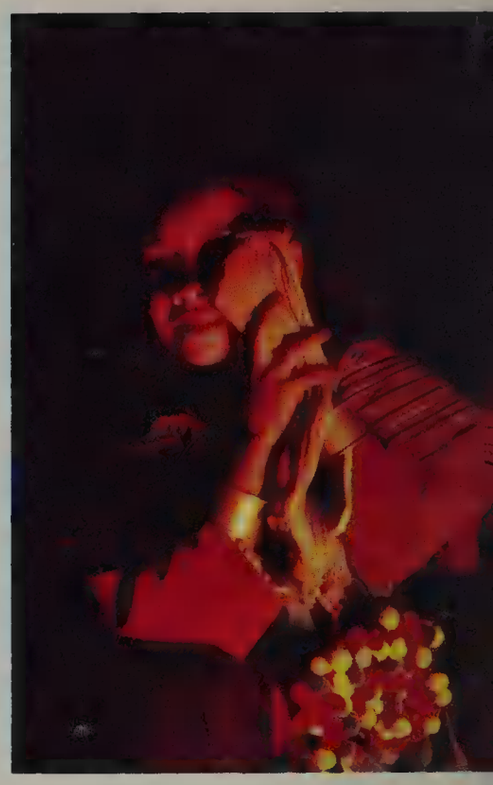

Lisu children

and for the quality of its analyses. There are nevertheless some pitfalls to keep the student awake: a clarifying footnote should certainly have been added to the statement that "most Pwo Karen, Lahu Nyi, Lisu, and Northern Thai avow Buddhism." An accompanying table that indicates 61.1 percent of Pwo Karen, 71 percent of Lahu Nyi, and 81.8 percent of Lisu in a survey group were Buddhists proves only that the group was unrepresentative or adept at answering questionnaire incorrectly. The majority of the first three hill tribes are still animists.

An interesting chapter by Erik Cohen discusses tourism in the highlands, a phenomenon that began about fifteen years ago and has accelerated since. Whereas ten years ago few highlanders ventured into Chiang Mai, northern Thailand's only city, Hmong and a few other tribals are now regular vendors at the colorful night bazaar that spills over into the downtown streets. Thai, Chinese, Burmese, Indian, Europeans, Australians, and Americans jostle each other. In spite of the language problems, the tribal merchants are equally astute with a French tourist or a Bangkok Thai. They sell not only items from their own villages but also those of other hill tribes and even resell Thai, Burmese, and Nepalese trinkets. In addition some three dozen small tour operators offer treks to hill tribe villages. The customers are mostly young Americans or Europeans with little knowledge of the customs or languages of the people they visit. Some frequently visited villages have come to rely on the sale of souvenirs (they are no longer handicrafts, and some items, such

John Hobday, *Peoples of the Golden Triangle*

tablecloths and placemats, have no ıce in traditional culture). Homemade othing and homespun cloth is rapidly ing way to Japanese synthetics and othing made on sewing machines. There e changes in highlander behavior, ought, and values as well. The danger is at these villages are fast becoming hun zoos: their inhabitants are inured to e outsiders who come to stare and photoaph them for a few minutes or hours, en leave.

A sign I recently saw in Chiang Mai ems to sum up the changes that have en wrought these past ten years: Newly discovered hill tribe village! Only ır groups have visited before! Three-day k leaves Thursday, 600 baht!" (about 0). Even the tour operators recognize at once a village has been visited by too any tourists, it is spoiled and no longer orth as much. Yet the tour operators emselves are participating in the deuction of traditional cultures. And by blicizing "little known" cultures to the tside world, do the recent books about e hill tribes of Thailand also contribute their destruction? Will the information ntained in these books lead to more ranal policies or behavior on the part of tsiders or will it merely pique our curiosand further encourage more gawking arists?

ain Y. Dessaint is Asian specialist with e Business Council for International derstanding in Washington, D.C. His norities of Southwest China was published in 1980 by Human Relations Area les, New Haven, Connecticut.

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LaRue-Pine Hills, Illinois

by Robert H. Mohlenbrock

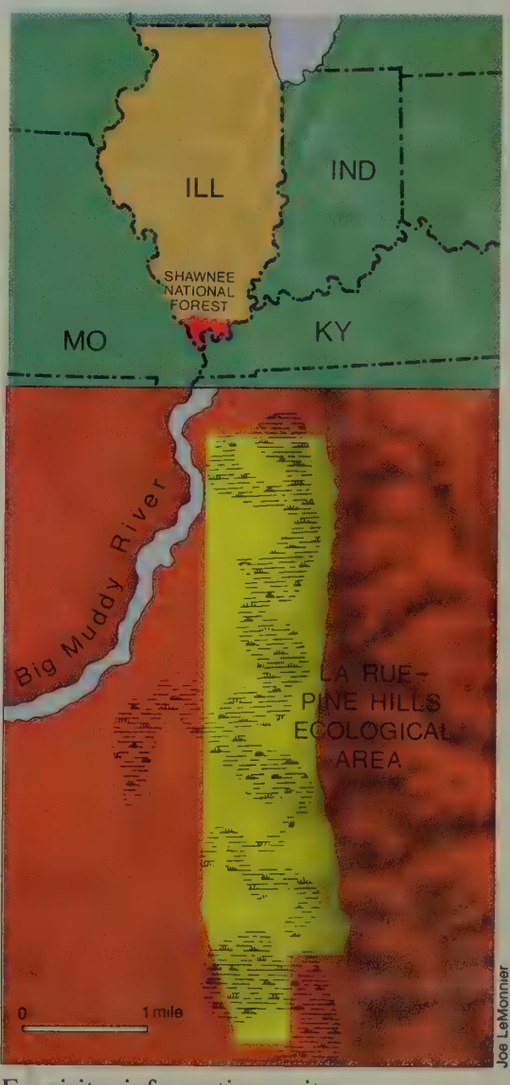
Not long ago I guided a group of naturalists from Chicago through an area in southwestern Illinois just forty miles from where I teach. As we stood before a spring-fed swamp that stretched to the base of 350-foot bluffs, one member of the group exclaimed appreciatively, "It sure doesn't look like Illinois!" No, LaRue-Pine Hills, a five-mile by two-mile strip running north–south in the Shawnee National Forest, does not evoke the flat fields of corn and soybean that dominate the central and northern portions of the state. Instead, one finds limestone cliffs like those in the Missouri Ozarks, swampland that mimics parts of Louisiana, and densely wooded ravines reminiscent of the Appalachians. The plant and animal life also reflects a relationship to these peripheral areas.

Several events shaped the character of the region and made it a biological crossroads. The uplifting of the Ozark Mountains, the inward spread of shallow Paleozoic seas, the crushing and crunching of continental glaciation, the strong westerly winds blowing across the prairies and plains, and the development of the Appalachian Range have all left their mark. As a result, LaRue-Pine Hills is the most diverse natural area of its size in the Midwest and possibly in the entire nation. Biologists who have used it as an outdoor laboratory for more than a century have found that it supports a wide selection of Illinois's plant and animal species, including some that are otherwise rare in the state. Unfortunately, certain of them have been nearly extirpated by overzealous collectors. Prodded by local naturalists, the U.S. Forest Service now manages LaRue-Pine Hills as an inviolate ecological zone, where plants, animals, and all things natural are not to be disturbed.

The Pine Hills part of the name refers to a pine-laden ridge of chert-bearing limestone that extends along the eastern edge of the area. The sheer, west-facing limestone cliffs, with steep, gravelly talus slopes, result from the same uplifting that, some 400 million years ago, created the Ozark Mountains to the west. As in adjacent southern Missouri, some of the limestone has dissolved, exposing acidic, orange-red pebbles of chert. Plants adapted to this habitat in Missouri have also found a home in this corner of Illinois. One is the shortleaf pine, whose presence was cause for comment as early as 1860, when Dr. Frederick Brendel, an immigrant German physician who lived in Peoria, wrote of it in *Prairie Farmer* magazine. Aside from a few ridges in the Pine Hills, this tree inhabits only one other Illinois location, although it is abundant in the Missouri Ozarks. Growing in the chert beneath the pines are pink azaleas, also confined in Illinois to this extension of the Ozarks. Other species range from colorful wildflowers, such as Boott's goldenrod and bird's-foot violet, to inconspicuous grasses and sedges.

The dry, rocky ridges also support numerous post oaks, blackjack oaks, black hickories, and red cedars, which grow stunted and gnarled in response to the harsh environment. Hikers clambering over the ridges are often surprised to emerge abruptly from the woods into grassy, treeless areas. Because these isolated openings harbor some of the same kinds of plants common to the great prairies to the west, they are called hill prairies. In the Pine Hills, they range in size from less than an acre to about two acres, although farther north on the bluffs along the Mississippi River, hill prairies may extend over several hundred acres. They develop mostly on west-facing slopes, where the hot afternoon sun beats down relentlessly on summer days, causing such dryness that trees cannot grow. Westerly

LaRue-Pine Hills



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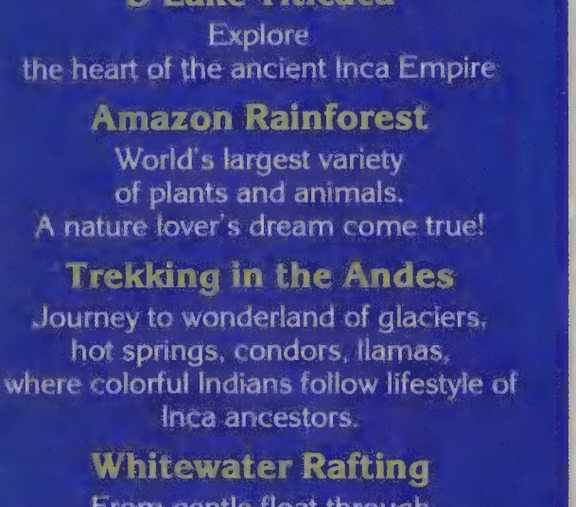

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Robert H. Mohlenb

The yellow-flowered bladderwort of LaRue Swamp.

winds, which contribute to drying the slopes, pick up seeds from the prairies and plains and propel them eastward to lodge in these openings. They sprout into grasses, such as big and little bluestems, Indian grass, and the curious-looking side oats grama, and into showy wildflowers, such as pink prairie phlox, yellow prairie evening primrose, butterfly weed, prairie clovers, and rosinweeds.

The rare eastern wood rat builds its nests of twigs and leaves along the narrow ledges of the limestone cliffs. This is a true pack rat, usually incorporating anything it can find into its nest. At some time long past, it probably migrated into the Pine Hills from the Missouri Ozarks. Another phenomenon of the erosion-pocked cliff faces is one 200-foot stretch that is a haven for small evergreen ferns known as spleenworts. No fewer than nine different kinds grow here, more than at any other place in the world. Why there are so many, biologists aren't sure, but in the crevices of chert and limestone, side-by-side combinations of acidic and basic soils vary to an extent rarely repeated in nature.

At the foot of the limestone cliffs and talus slopes lies a vast area of standing water known as LaRue Swamp. Named after a now-abandoned whistle stop along the nearby Missouri Pacific railroad, the swamp is partly fed by clear springs that issue from the base of the cliffs. These water sources harbor the Ozark spring cave fish, a small, blind organism whose eyesight became dispensable as it evolved in the darkness of springheads. As its name implies, this fish is associated with similar springs in the Missouri Ozarks.

After the uplifting of the Ozarks, Pale zoic seas covered the low-lying areas southern Illinois. When these shallow w ters subsided, the extensive swampla left behind became inviting habitat f scores of coastal plain species. Organisr migrated up the Mississippi Embayme the tongue-shaped trough that exten from near the mouth of the Mississip River north into southern Illinois. A though the swamps now remaining are b vestiges of a former era, migratory bir that land in the wetlands probably co tinue to carry plant species along this co ridor. Among the species that establish themselves in LaRue Swamp were t rusty-flowered swamp iris and the spon plant, a floating, flowering plant whc leaf cells inflate with gas bubbles to ke the heart-shaped leaves buoyed up to t water's surface. Other southern plant sp cies include the tupelo gum and pumpk ash, two trees whose swollen trunk bas help anchor them in their watery hon The southern rice rat also made its w northward into the swamp, as did lar numbers of fish, reptiles, and amphibia including the banded pygmy sunfish a the green water snake.

Floating on the surface of LaR Swamp, often in sufficient numbers to c scure the water completely, are duc weeds, the smallest flowering plants in t world. Each one consists of a tiny gre body, which may or may not have roo The tiniest of all is *Wolffia*, with a bo less than one millimeter in diameter. C rare occasions, duckweeds produce flo ers so minute that they can only be se through a microscope. Botanists recogni

ɔut thirty different kinds of duckweeds
he world, including seventeen in North
nerica; of these, eleven appear in
Rue Swamp. Occasionally interrupting
continuity of the duckweeds are
tches of wine-colored, floating mosquito
n and yellow-flowered bladderwort.
e latter's underwater structures bear
y traplike bladders that suck in minute
uatic animals for nutrition.

On slightly elevated areas adjacent to
swamp, in the coves of the limestone
ffs, the rich, moist land supports stately
ests of tulip poplar, American beech,
cumber magnolia, and Ohio buckeye,
es with an Appalachian connection.
veral hundred miles to the east, the
ɔpalachian Range is four to five thou-
nd feet above sea level. The drainage
tterns that have developed from the
ɔpalachians have opened up paths of mi-
ation through which these elements
ay have come. The cool, moist coves are
o perfect for spring wildflowers that are
ted to the shade. Freed from compe-
ion, they grow so thickly that walking
thout trampling them is difficult. There
ɔne acre of uninterrupted bluebells; an-
ner cove is filled with Gleason's white
llium and yellow celandine poppy; else-
ere, Miami mist forms a light blue haze
ross the forest floor.

Four great glaciers have ground their
y south into Illinois, pushing before
em anything that stood in the way. The
epest penetration, made by the Illi-
isan glacier some 200,000 years ago,
ɔpped a few miles north of LaRue-Pine
lls, but the groundwork was established
new routes of migration for plants and
imals. The bulblet hemlock, a yellow
ɔsestrife known as swamp candles, and
ch fish as the spottail shiner and the
rthern hog sucker may have reached
Rue-Pine Hills along this pathway.

The area's diversity seems inexhaust-
e. Kenneth Weik, a botanist at Lake
rest College, studied LaRue Swamp for
achelomonas, a genus of microscopic,
glenalike algae. His identification of
irty-three different species of these
een spheres—including two new to sci-
ce—tripled the number previously
own in the state. Not to be outdone, Jay
cPherson of nearby Southern Illinois
niversity has recorded fifty kinds of
nkbugs from the Pine Hills; possibly the
gion now deserves the unenviable title of
Stinkbug Capital of the World."

*This Land" highlights the biological
enomena that can be explored in the 153
S. national forests. Robert H. Mohlen-
ock is a professor of botany at Southern
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The Case of Johanna's Quail

Can a new recipe be a success not only on the dinner table but also in a court of law?

by Raymond Sokolov

In the supermarket yesterday, we bought a package of four frozen quails. The plump little birds cost less than $3, which made us feel good about the world. And we felt even better when we ate them at Sunday lunch, after having spent an absolute minimum of time with culinary fussing.

The basic recipe came right off the package the birds were sold in. It advised moistening the quails in "Italian salad dressing," then broiling them over an outdoor fire for twenty-five minutes, and basting them with more dressing every five minutes.

Much was left out in this recipe. It gave the consumer no sense, for instance, of how close to the outdoor fire the birds should be. More important, it made no specific recommendation about the contents of the "Italian" dressing. Still and all, it was hard to go wrong, and the tackiness of the recipe concealed its basic similarity to a great many, much more sophisticated recipes that essentially consist of meat marinated in a flavored vinaigrette dressing and then broiled or roasted.

This procedure is at the heart of almost all barbecuing and of much classic game cookery. Therefore, sensing where we were on the culinary map, we went ahead with the manufacturer's recipe, modifying it in a way that was uniquely ours but heavily dependent on tradition. We mixed up our own vinaigrette, soaked the birds in it, and then set them to broiling in the oven. At a certain point about halfway along, my wife was inspired to smear the quails with red currant jelly, which is a traditional component of game sauces. The jelly was at room temperature—therefore solid and hard to spread. It fell off the quails into the pan, where it melted into the juices that had collected there. Seeing that she had inadvertently created a fine basting liquid, but having no baster at hand, she took tongs and stirred the little birds through the liquid in the pan, efficiently coating them with it.

The finished quails were delicious. And I think Mrs. Sokolov is entitled to claim this method as her own and to publish the recipe as "Quail Johanna" or even "Cailles Rôties à l'Instar de Jeanne." And until recently I would have thought that nothing in the law then prevented a reader from republishing the same recipe as his own, for example as "Roast Quail Casimir O'Brien." Certainly, nothing I knew of, beyond common decency or the risk of being stigmatized by other food writers, would have compelled Mr. O'Brien to seek permission from Johanna for the use of her work.

All that may have changed last su
mer, when the American expatriate co
ing teacher Richard Olney took legal
tion against the book *Richard Nelso
American Cooking* and its publish
New American Library (NAL). Oln
claimed the new book contained thir
odd recipes plagiarized from his much
mired *Simple French Food* (Atheneu
1974).

In a consent judgment, NAL agreed
stop publishing and selling the Nels
book, and Olney was paid an undisclos
sum reported to be in the low five figur

A consent judgment does not have
effect of legal precedent, but the Nels
case could have what lawyers call a ch
ing effect on people who used to feel
compunction about borrowing the recip
of others and reprinting them without p
mission or attribution.

In the bad old days before the Nels
case, publishing lawyers would advise y
that no one could assert a right of prope
in an individual recipe. Originality
method was almost impossible to pro
while originality of expression was an e
nescent concept, easy to muddle with
change of a line or a phrase that would
able a pirate to claim the slightly edit
new text as his own.

Apparently, if the Nelson case is a s
of the way judicial winds are blowi
Johanna's quail recipe (which I have pu
lished here with her permission and for
consideration of one new Bolivian alpa
sweater, brown, purchased at the gift sh
of the Organization of American States
Washington, D.C., for an undisclos
price in the high two figures) is now
fendable as private property.

While I am glad and proud about t
particular turn of events, I question

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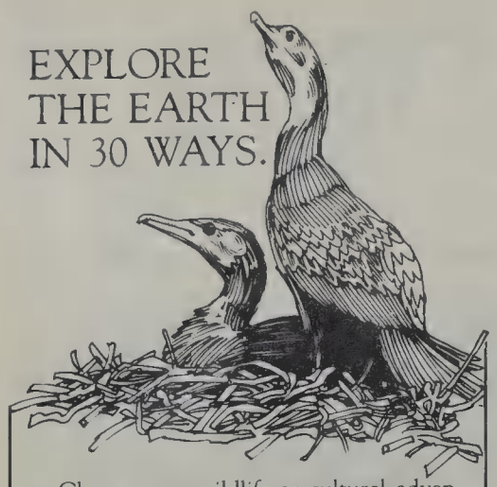

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logic apparently underlying the Nelson-Olney agreement, which is, at any rate, difficult to specify, since the court did not enunciate a doctrine.

Did the case hinge on the weak argument that the formula expressed in Olney's recipes was uniquely his? Cooking is not, after all, a field like chemical engineering, in which new discoveries are made daily and promptly reported in journals where they can be easily retrieved and identified. Indeed, almost no cookbook writer alive today does more than recombine processes invented long ago and reinvented by many hands thereafter. Perhaps, every once in a great while, someone will hit upon a new way of, say, poaching eggs, but this is a rare occurrence at best.

More often, improvisation in the kitchen will produce a dish a good cook thinks is original in the way that it recombines standard ideas. I think Johanna's quail is such a recipe. I also think it would be impossible to prove that claim in court. How can we be sure that no one in all of recorded and unrecorded time didn't slip currant jelly into pan drippings, then douse a quail with the resultant juice?

The Nelson-Olney agreement, if it is based on anything of substantial plausibility, was most probably based on uniqueness of language. In other words, if Mr. O'Brien should happen to reprint the verbatim text of the recipe below, without permission or attribution, he would have exceeded the bounds of fair use, and Johanna Sokolov could sue him with a fair presumption of making him wince in his pocketbook.

Naturally, I am inclined to see justice in this, as it affects my helpmeet (and my own rights over my own text). But in that parenthesis lies the heart of the matter. I wrote the text, which is, I think, the only aspect of the recipe that anyone can securely own. Doesn't this state of affairs give too much to the person who happens to write things down, even if it is written with astonishing and memorable clarity and flair?

Well, I'm not sure, but I do know that I always feel a twinge of thief's guilt when I transcribe an interviewee's unpublished recipe and then print it in this magazine, even though I make attribution to the source. Obviously, I don't intend to argue that the food writer plays a trivial role in the transmission and preservation of traditional food ideas. Actually, I see this anthropological side of food writing as more important than anything else in gastronomy except cooking itself. And it is precisely his anthropological contribution that I prize so highly in Richard Olney's *Simple French Food*.

In the preface, Olney writes: "The fo in this book has been culled from all t corners of France. . . . " And he goes on express "an uneasy sense of the gentle d sipation of regional culinary traditions a the need to succor them."

This praiseworthy impulse—to save t gently dissipating regional traditions France (particularly of Provence, whe he makes his home)—must logically r on Olney's direct experience of those t ditions. Olney learned about simp French food from French people, son how, somewhere. It takes away nothi from the high value of his book—one the best cookbooks produced in an era ri in cookbooks—to say that he owes its co tents to the cooks and cookery authors France, present and past, who have inf enced him. And I do not think that Oln would dispute this point in the slightes

He does, indeed, from time to time, lude to other people who have cooked recorded the food that interests him. Bu think it is fair to say that he does not ma a regular effort to tell readers of *Simp French Food* where he found out abou clearly traditional dish like *Estofinade la rouergatte*, a mixture of salt cod a sliced, boiled potatoes that presumal Olney owes to cooks of the Rouergue d trict. He does go so far as to imply that recipe modifies tradition by substituti salt cod for stockfish: "Stockfish is at t origin of the preparation—but stockf requires a number of days more soaki than salt cod. . . . " But where did Oln acquire his knowledge? Was the dish ready being done with salt cod when first came upon it or did Olney hims make the substitution? It would be nice know at which point the gifted Americ cook-anthropologist intervened and p his own mark on the recipe.

My interest in this question is not the terest, primarily, of a professional curio about Olney's public claim of originalit want to know where tradition ends a Olney begins because I care about the p rity of food ideas, but most of the tim can't tell when he is being a direct cond of recipes gleaned from living informan when he is synthesizing various versions a dish into a version that appeals to him, when he is inventing a dish based, more less, on French practice but branching from it in a personal way. An example the latter possibility is Olney's recipe fo fresh fig, prosciutto, and mint sala Olney is quite open about the novelty adding mint (as a flavoring for a crea sauce and as a garnish) to the traditio combination of figs and ham.

But if he feels free, as indeed he shou to build on French ideas in his own way,

ld be more explicit in telling readers
n he departs from sources and what
e sources are.
realize that I am insisting on a very
standard of disclosure here. But
y has defended the originality of his
in *Simple French Food* with great
city. He told the *Washington Post*, "I
to scare a few plagiarists to death."
ne estimate, the Nelson lawsuit cost
\$250,000. And it has certainly
ed Nelson himself much pain and
ic humiliation. So it seems only fair
Olney should at least give credit to
people who taught him the recipes he
cted and distilled (for all one can tell
most of them, he may simply have
informants' procedures into conven-
l recipe English) and then included in
book he so fiercely defends as his own.
et me be very clear about this. I be-
that the book is in every legal and
l sense Richard Olney's book. I am
suggesting that the sophisticated act
riting down traditional procedures
not eliminate or supervene upon the
s of traditional cooks, for whom we
ern food writers are merely educated
ts.

*mond Sokolov is a writer whose spe-
nterest is the history and preparation
od.*

Johanna's Quail

Quails
cup olive oil
tablespoon tarragon vinegar
Salt
Pepper
tablespoons red currant jelly

Preheat broiler.
Meanwhile marinate quails in a "salad
ressing" stirred together from the oil,
inegar, salt, and pepper.
Set the quails in a roasting pan and
place 6 or 7 inches from the broiler
lame or element.
Turn the birds every five minutes or so
nd baste, each time you turn them,
ith the remaining vinaigrette.
After 15 minutes, swirl the currant
elly into the pan juices. Using tongs,
ip the birds into the jelly and pan
uice mixture to coat both sides. Con-
inue broiling for another 10 minutes,
urning once more. The birds are done
hen they have browned outside and
he juices from the breasts run clear.
Serve immediately. Eat with your
ands; quails are too small to cut prof-
tably with a knife and fork. Steamed
ennel makes a fine side dish.

Yield: 2 servings

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Jellyfish, Sunny Side Up

Human beings spend thousands of dollars and travel almost as many miles just to lie down in the sun, and they're not the only ones who take some trouble to expose themselves to that fire. Frogs bask, and the hotter the spot the better; sunflowers dutifully follow their namesake all day; night herons perch on treetops to have a more intimate audience with the sun. But one of the champs of sun worship has to be the mangrove jellyfish, *Cassiopeia xamachana*, which has literally turned its life upside down for love of a good photosynthate. Sometime during its evolution, this jellyfish, which carpets the floor of many a Florida mangrove swamp, rolled over onto its bell and then stayed there. It lives in shallow water and its arms, instead of hanging down, drift upward—partly because of the bell's pulsations.

Why go through all these changes for the sun? A number of scientists think it's because of an alga, *Symbiodinium microadriaticum*, that lives symbiotically within the jellyfish. According to Mark Eakin and other researchers at the University of Miami, *C. xamachana* feeds on photosynthates—the excess oxygen and other nutrients produced by the algae when they photosynthesize during the day. In exchange, the algae borrow some nutrients from the jellyfish, get to live in a safe environment—living inside another creature has to be the ultimate way to keep predators from noticing you—and are protected from sudden changes in the environment. If that weren't enough, the jellyfish gently raises its arms to bring the algae several inches closer to the desired object.

The sun is also much desired by photographers, although they turn their backs on it as much as possible. Jeff Foott had his back to the sun and his feet buried in the muck of a central Florida swamp when he leaned over to take this picture. But something stopped him. The lighting wasn't right; he didn't know if he would have a clear shot to the bottom. So Jeff Foott hooked up a strobe to his camera and then went back to his work. He didn't mean any disrespect. But business, after all, is business.—*D.W.*

Photograph by Jeff Foott

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Communal Roosting (p. 34)

In "Two Principal Strategies in Avi Communal Roosts" (*The American N uralist*, vol. 121, pp. 237–43), P.J. Wea erhead summarizes current hypothes explaining why communal roosting c curs, then suggests a new theory "based the premise that not all individuals parti pate in the roost for the same reason." O theory reviewed in this article, the formation center hypothesis, is present by P. Ward and A. Zahavi in "The Imp tance of Certain Assemblages of Birds 'Information Centres' for Food Findin (*The Ibis*, vol. 115, pp. 517–34). The p dation avoidance hypothesis is discuss in D. Lack's *Ecological Adaptations f Breeding in Birds* (London: Methue 1968). For a good overview of social int actions among animals, including comm nal roosting, see chapter eight of Wittenberger's *Animal Social Behavi* (Boston: Duxbury Press, 1981).

Epiphytes (p. 42)

N. Nadkarni discloses some importa interactions between epiphytes and th host trees in a cover story for *Scien* "Canopy Roots: Convergent Evolution Rainforest Nutrient Cycles" (vol. 214, p 1023–24). Far less technical is D. Perr "An Arboreal Naturalist Explores t Rain Forest's Mysterious Canop (*Smithsonian*, June 1980, pp. 42–52). Benzing, known for his work on vascul epiphytes, writes about them in *The Bi ogy of the Bromeliads* (Eureka: M River Press, Inc., 1980), dealing with e erything from their taxonomy and classi cation through their cellular biolog physiology, nutrition, reproductive bi ogy, and ecology. Mad River Press's a dress is Route 2, Box 151-B, Eureka, C 95501. R. Kirk's *Exploring the Olymp Peninsula* (Seattle: University of Was ington Press, 1980), although written f the layperson, is scientifically accura Kirk briefly reviews the history of t area, covering its geology, plants a wildlife, and places of interest for visito

Rhesus Monkey (p. 62)

The Rhesus Monkey, edited by G. Bourne (New York: Academic Pres

ditional Reading

75), is a two-volume collection of arti-
s providing detailed scientific informa-
n about the animal, but it does not cover
population status. From 1960 to 1980,
pulations of rhesus monkeys in India de-
ned substantially, particularly in the ag-
ultural regions of the north. C.H.
ûthwick, M. F. Siddiqi, and J.R. Op-
nheimer examine this phenomenon in
wer y-Year Changes in Rhesus Mon-
y Populations in Agricultural Areas of
rthern India" (*Ecology*, vol. 64, pp.
4–39). See also "Rhesus Monkey Popu-
ions in India and Nepal: Patterns of
owth, Decline, and Natural Regula-
n," by Southwick et al., chapter 7 of
osocial Mechanisms of Population
gulation, edited by M.N. Cohen, R.S.
alpass, and H.G. Klein (New Haven:
le University Press, pp. 151–70); "Sta-
and Conservation of Rhesus Monkeys
India," by Southwick and Siddiqi, in
rspectives in Primate Biology, edited
P.K. Seth (New Delhi: Today and To-
rrow's Publishers, 1983, pp. 227–36,
tributed in the United States and Can-
a by Scholarly Publications, Houston,
X); "Population Dynamics of Rhesus
onkeys in India," also by Southwick and
ldiqi, in *Primate Conservation,* edited
H.R.H. Prince Rainier III and G.
urne (New York: Academic Press,
77, pp. 339–62); and "Population Pat-
ns and Behavioral Ecology of Rhesus
onkeys (*Macaca mulatta*) in Nepal,"
J. Teas et al., in *The Macaques: Stud-
in Ecology, Behavior and Evolution,*
ted by D.G. Lindburg (New York: Van
ostrand Reinhold, 1980, pp. 247–62).
Conservation and Management of Wild
mate Populations," by Southwick and
D. Blood (*Bioscience,* vol. 29, pp. 233–
), is a short article recommending con-
vation methods to stop the rapid deple-
n of wild primate populations. Finally,
o good books that cover both population
d behavior are A. Jolly's *The Evolution
Primate Behavior* (New York: Macmil-
n Publishing Co., 1985, second edition)
d J.H. Wolfheim's *Primates of the
orld: Distribution, Abundance and
nservation* (Seattle: University of
ashington Press, 1983).

Rita Campon

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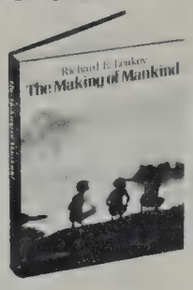

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Authors

A visit in the 1970s to a large bla bird roost at Fort Campbell, Kentuc sparked **Patrick J. Weatherhead**'s int est in the communal behavior of bi (page 34). During the past ten years, has done avian research at two sites the Canadian Arctic and at numer sites in the temperate zone. Born in L don, England, but now a Canadi citizen, Weatherhead received a Ph.D. biology from Queen's University Kingston, Ontario, and is an associa professor of biology at Carleton Univ sity in Ottawa. In addition to his search on birds, he has on occasi worked as a professional river guide fo white-water rafting company and has come an avid windsurfer.

The thrill of exploration—of being in
ace where no human has been before
where there is potential for discov-
g new phenomena and interac-
s—is what triggered my canopy re-
ch," writes **Nalini M. Nadkarni**
ge 42). Much of her work is done in
tops, and to reach them she had to
n mountain-climbing techniques.
dkarni, who studied with Charles
er, earned a Ph.D. in 1983 from the
lege of Forest Resources of the Uni-
sity of Washington in Seattle and is
assistant professor of biological sci-
es at the University of California,
ta Barbara. One of her future
jects will use three-dimensional com-
er graphics to map tree crowns and
plant communities they support.
en not swinging through the trees,
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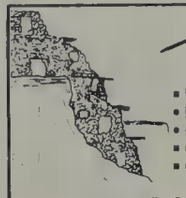

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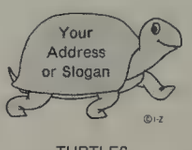

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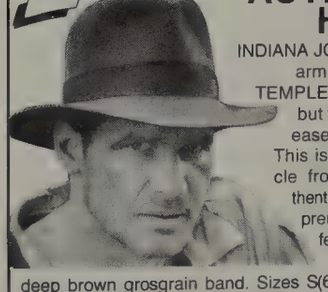

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Authors, continued

On his first visit to China in 1975, **Richard Gordon**, (page 52) lived and worked there for two and a half months—long enough to become obsessed with the country. Gordon has since made six trips to China,learned to speak Chinese, and worked in several villages and in a Shanghai factory. He has worked on assignment in China and on the Tibetan Plateau and his photographs have been featured in two *Natural History* stories, "Journey to the Tibetan Plateau" (September 1982) and "Growing Up in a Chinese Village" (November 1984). With Carma Hinton, Gordon has codirected two films: *Stilt Dancers* and *Small Happiness: Women of a Chinese Village*—both have been featured at the Margaret Mead Film Festival. A dropout from the University of Pennsylvania, Gordon hopes to find the time to return and resume his studies.

More than thirty years ago, **Charles Southwick**, left (page 62), was introduced to primate research in Panama while he was studying for his Ph.D. at the University of Wisconsin. Following his postdoctoral work at Oxford University, he conducted more than fifty overseas trips for field research in animal ecology and behavior, primarily in Asia. Southwick taught at Hamilton College, Ohio University, and the Johns Hopkins University, and since 1979, has been a professor of biology at the University of Colorado, where he teaches global ecology and primate studies. His coauthor and colleague of many years in India, **M. Farooq Siddiqi**, right, is an associate professor of geography at Aligarh University. He received his B.A. from Agra University, and his M.A., L.L.B., and Ph.D. from Aligarh University. In addition to his work in primate ecology, Siddiqi is editor of the *Geographer* and a specialist in the economics of village agricultures. Southwick and Siddiqi share keen interests in animal populations, environmental quality, conservation, and human affairs.

"I've got the best job in the world," brags **Jeff Foott** (page 94), a naturalist and photographer. "I can pick out a subject and then go right to the expert and spend more time with him than I would if I were his graduate student." Foott, who grew up in Berkeley, started studying science—in his case marine biology—but found the academic route confining. Working in the field, however, looking "for portraits that have been sculpted over tens of thousands of years," suits him fine. When he comes across a wonderful sight, he goes to the experts. His photograph of an upside-down jellyfish in *The Natural Moment* was shot with a 55-millimeter macro lens.

Sex and the Single Chickadee

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NATURAL HISTORY

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URAL HISTORY *(ISSN 0028-0712) is*
lished monthly by the American
seum of Natural History, Central Park
t at 79th Street, New York, N.Y. 10024.
scriptions: $18.00 a year. In Canada and all
r countries: $23.00 a year. Second-class
age paid at New York, N.Y. and at
itional offices. In Canada second-class postage
l at Windsor, Ontario (permit no. 9579).

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Letters

The Sons of India

The informative article by Stanley Freed and Ruth Freed, "One Son Is No Sons" (January 1985) includes what I think is an error. It is stated that the practice of voluntary sterilization after a specified number of sons have been born is responsible for an increased proportion of males in the population of Shanti Nagar, India.

Here is one way to look at the problem: Since the decision to stop having children cannot change the sex of children already born, it cannot change the overall sex ratio. It can, of course, change the relation between sex ratio and family size; smaller sibships will have more males. The size of the sibship is something over which the parents *do* have control. Sterilization might lead to a distorted sex ratio in the sterilized sibships if these constitute an atypical subset of the population. But change the overall sex ratio it won't.

The same false argument, based on stopping further births after an heir is born, has been invoked to explain a reputed excess of males in royal households.

It is necessary to look elsewhere for an explanation of the increased proportion of males in Shanti Nagar.

JAMES F. CROW
Professor of Genetics,
University of Wisconsin,
Madison, Wisconsin

The authors reply

Professor Crow is correct. Sterilization cannot ordinarily affect the proportion of males and females in a population. We regret the error and thank the readers who wrote to us, thereby permitting the prompt publication of this correction. We especially hope to avoid the possibility that our statistical mistake may be interpreted as casting a shadow on the Indian policy of encouraging voluntary sterilization. There was, of course, no such intent. The sex ratio in the village of Shanti Nagar nevertheless typifies the situation in northwestern India, where high male-to-female sex ratios are a longstanding phenomenon. Various explanations have been advanced, including the systematic mistreatment of female children or their possible undernumeration in censuses. A number of causes may be involved, and the problem merits further study.

The major theme of the article remains valid, however—the conflict between governmental attempts to limit family size and the preference for sons as security and support for the elderly. Discussions of population control in India usually emphasize the increasing number of persons who undergo sterilization or who accept family planning. The other side of the coin, the number of surviving children that a couple has at the end of childbearing, receives less attention. Thus people are sometimes surprised that the growth rate of the population has not as yet declined. In an excellent evaluation of the most recent Indian census (1981), which appeared in India's *Economic and Political Weekly*, Pravin Visaria and Leela Visaria write that "the Department of Family Welfare estimates that 42.8 million births had been 'averted' in the 28 years since the [family planning] programme's inception—37 million of them in the decade between the censuses of 1971 and 1981. This may seem a commendable achievement but it failed to make a dent in India's population growth rate during the past decade."

STANLEY A. FREED
RUTH S. FREED

Bat Agony

One can only hope that in some other dimension when Raymond Mendez ("The Natural Moment," October 1984) lies helplessly screaming while being eaten alive by Trinidadian cockroaches, a young bat happens by who has more clearly and justly resolved not only the issue of man's interference in natural systems but also of suffering—and acts more quickly and humanely to alleviate his pain, natural or not.

RUTH A. CAMPO, M.D.
Rutherford, New Jersey

In all my long years of reading *Natural History*, I have never felt the need to write a letter, but I was very moved by the dramatic photograph in the October "Natural Moment." The death of the baby bat presents nature at her grisliest, and I don't

ubt that I would have given the bat the
ne *coup de grâce*. Bravo.

DAVID STEVER
Saint Paul, Minnesota

The photograph is certainly stunning,
d the article is powerful; my criticism is
directed at the skill involved in the pro-
ction of the feature. I just wish someone
d said, wait a minute—do we really
nt to zap them with this one?

JULIA C. SCHIEFFELIN
New York, New York

nsumer Fraud

Tom Eisner's photograph ("The Natu-
Moment," November 1984) of a fly
sing as a spider is quite captivating. The
ry behind the photograph is also rather
eresting, particularly the final para-
ph. There it is disclosed that Mr.
ner placed the fly "in a refrigerator for
hile to slow it down" and later removed
nd took the picture. This would seem to
icate that "The Natural Moment" was
so natural after all. I do not believe
t the fly suffered any injustice; as for
ur readers, however, the subtitle "Con-
ner Fraud" seems to be (in a round-
out way) somewhat appropriate.

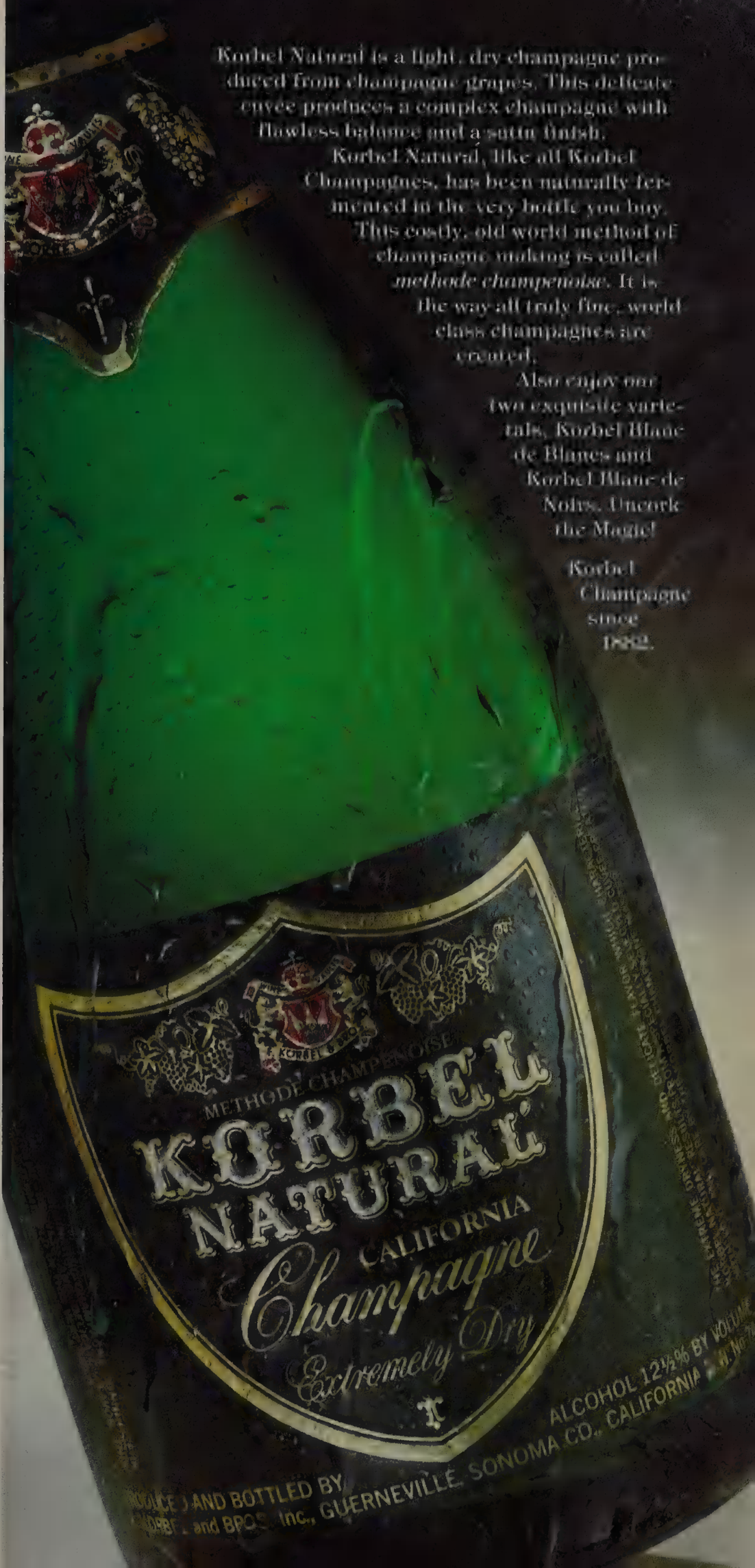
THOMAS GOEBEL
Bolivar, Missouri

e Johnsons' Paradise

I thoroughly enjoyed "Shooting in Par-
se" (December 1984). In the last few
rs, I have collected, read, and enjoyed
tually all of the Johnsons' books.
I am writing in hope that you can an-
er a question—where (exactly) is Lake
radise?

DAVID P. KELLY
Westport, Connecticut

*ke Paradise is in the Gof Sokorte Guda
ter at the top of Mount Marsabit in
thern Kenya. It is accessible by road,
d there is a modest airstrip nearby. Un-
tunately, heavy poaching of elephants
the 1970s severely depleted the ele-
ant herds, and more recently, droughts
ve caused the temporary disappear-
ce of Lake Paradise, which depends on
nfall as its source of water.—D.J.P.*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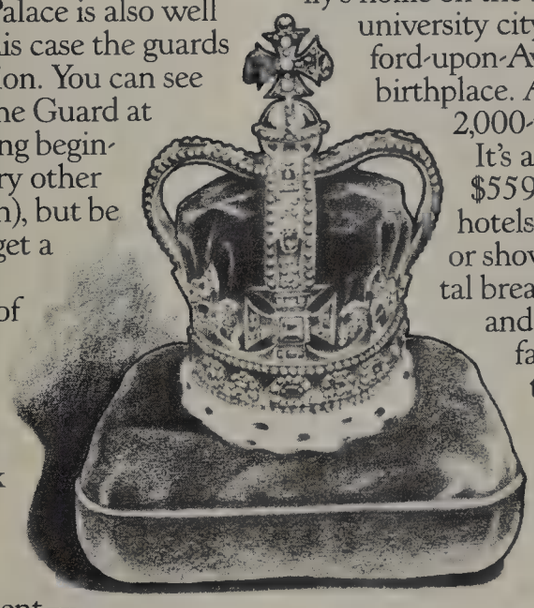

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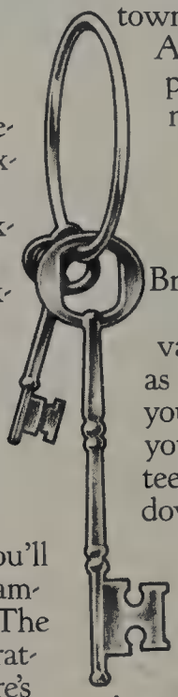

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The Flamingo's Smile

Ironically, Darwin often gets credit for Lamarck's great contribution to evolutionary theory

by Stephen Jay Gould

Buffalo Bill played his designated role in reducing the American bison from an estimated population of 60 million to near extinction. In 1867, he and his men killed 4,280 animals in just eight months, under a contract to provide food for railroad crews. His slaughter may have been indiscriminate, but the resulting beef was not wasted. Other despoilers of our natural heritage killed bison with even greater abandon, removed the tongue only (considered a great delicacy in some quarters), and left the rest of the carcass to rot.

Tongues have figured before in the sad annals of human rapacity. The first examples date from the most infamous episodes of gastronomical gluttony—the orgies of Roman emperors. Mr. Stanley, Gilbert's "modern major general," could "quote in elegiacs all the crimes of Heliogabalus" (before demonstrating his mathematical skills, in order to cadge a rhyme, by mastering "peculiarities parabolous" in the study of conic sections). Among his other crimes, the licentious teen-aged emperor presided at banquets featuring plates heaped with flamingo tongues. Suetonius tells us that the emperor Vitellius served a gigantic concoction called the Shield of Minerva and made of parrotfish livers, peacock and pheasant brains, lamprey guts, and flamingo tongues, all "fetched in large ships of war, as far as from the Carpathian sea and the Spanish straights."

Lampreys and parrotfishes (though not without their beauties) have rarely evoked great sympathies. But flamingos, those elegant birds of brilliant red (as their name proclaims), have inspired passionate support from the poets of ancient Rome to the efforts of modern conservationists. In one of his most poignant couplets, Martial castigated the gluttony of his emperors (ca. A.D. 80) by speculating about different scenarios, had the flamingo's tongue been gifted with song like the nightingale's, rather than simple good taste:

Dat mihi penna rubens nomen; sed lingua gulosis
Nostra sapit: quid, si garrula lingua foret?

(My red wing gives me my name, but epicures regard my tongue as tasty. But what if my tongue could sing?)

Most birds have skinny pointed tongues, scarcely fit for an emperor, even in large quantities. The flamingo, much to its later and unanticipated sorrow, evolved a large soft, fleshy tongue. Why?

Flamingos have developed an exceedingly rare mode of feeding, unique among birds and evolved by very few other vertebrates. Their bills are lined with numerous, complex rows of horny lamellae—filters that work like the whalebone plates of giant baleen whales. Flamingos are commonly misportrayed as denizens of lush tropical islands, something amusing to watch while you sip your rum and Coke on the casino veranda. In fact, they dwell in one of the world's harshest habitats—shallow, hypersaline lakes. Few creatures can tolerate the unusual environments of these saline deserts. Those that thrive can, in the absence of competitors, build their populations to enormous numbers. Hypersaline lakes therefore provide predators with ideal conditions for evolving a strategy of filter feeding—few types of potential prey, available in large numbers and at essentially uniform size. *Phoenicopterus ruber*, the greater flamingo (and most familiar species of our zoos and conservation areas in the Bahamas and Bonaire), filters prey in the predominant range of an inch or so—small mollusks crustaceans, and insect larvae, for exam ple. But *Phoeniconaias minor*, the lesse flamingo, has filters sufficiently dense an efficient to segregate cells of blue-gree algae and diatoms with diameters of 0.0 to 0.1 mm.

Flamingos pass water through their bi filters in two ways (as documented in th classic article by Penelope M. Jenkin "The Filter Feeding and Food of Flamin goes," *Philosophical Transactions of th Royal Society of London*, 1957, vol. 240 pp. 401–93): either by swinging thei heads back and forth, permitting the wa ter to flow passively through, or by th usual and more efficient system that in spired the Roman gluttons—an activ pump maintained by a large and powerfu tongue. The tongue fills a large channel i the lower beak. It moves rapidly back an forth, up to four times a second, drawin water through the filters on the backwar pull and expelling it on the forward drive The tongue's surface also sports numerou denticles that scrape the collected foo from the filters (just as whales collect kri from their baleen plates).

The extensive literature on flamingo has highlighted the unique filters in its dis cussion of feeding—and often neglecte another, intimately related featur equally remarkable and long appreciate by the great naturalists. Flamingos fee with their heads upside down. They stan in shallow water and swing their head down to the level of their feet, subtly ad justing the head's position by lengthenin or shortening the S curve of the neck This motion naturally turns the head up side down, and the bills therefore revers their conventional roles in feeding. Th anatomical upper bill of the flamingo lie

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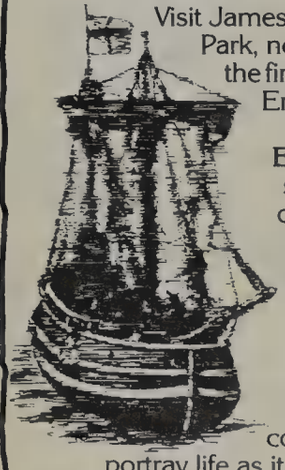

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beneath and serves, functionally, as a lower jaw. The anatomical lower bill stands uppermost, in the position assumed by upper bills in nearly all other birds.

With this curious reversal, we finally come to the theme of this essay: Has this unusual behavior led to any changes of form and, if so, what and how? Darwin's theory, as a statement about adaptation to immediate environments (not general progress or global direction), predicts that form should follow function to establish good fit for a peculiar life style. In short, we might suspect that the flamingo's upper bill, working functionally as a lower jaw, might evolve to approximate, or even mimic, the usual form of a bird's lower jaw (and vice versa for the anatomical lower, and functionally upper, beak). Has such a change occurred?

Such curious exceptions provide our best tests for general rules. Nature harbors a large suite of oddities so special that we scarcely know what to predict. But, in this case, we encounter a precise reversal of anatomy and usual function—leading to a definite expectation: do upside-dow animals reorient the form of their bodie to a new function when current behavio and conventional anatomy conflict?

We may begin by sparing the usual por tification (but only for a while) and lookin at a picture (on the old idea that we gai thereby at least a thousand words, or abou one-third my assigned length—though usually manage to exceed the limit). If thi picture (below) excites a vague feeling o familiarity slightly awry, your perception are acute, but ride with me for a while.

We seem to see a long-necked swa with a broad smile. But look carefully, fo details betray this impossible beast. It mouth opens *above* the eyes; its feather run the wrong way; and where are its legs I next show you the celebrated original i its proper orientation (and with the legs re stored)—the flamingo from J.J. Audu bon's *Birds of America*, and a sure entr on anyone's hit parade of most famous pic tures in natural history.

This dramatic perceptual switch fron happy swan to haughty flamingo recall

Does this strange bird seem familiar? (See page 10)

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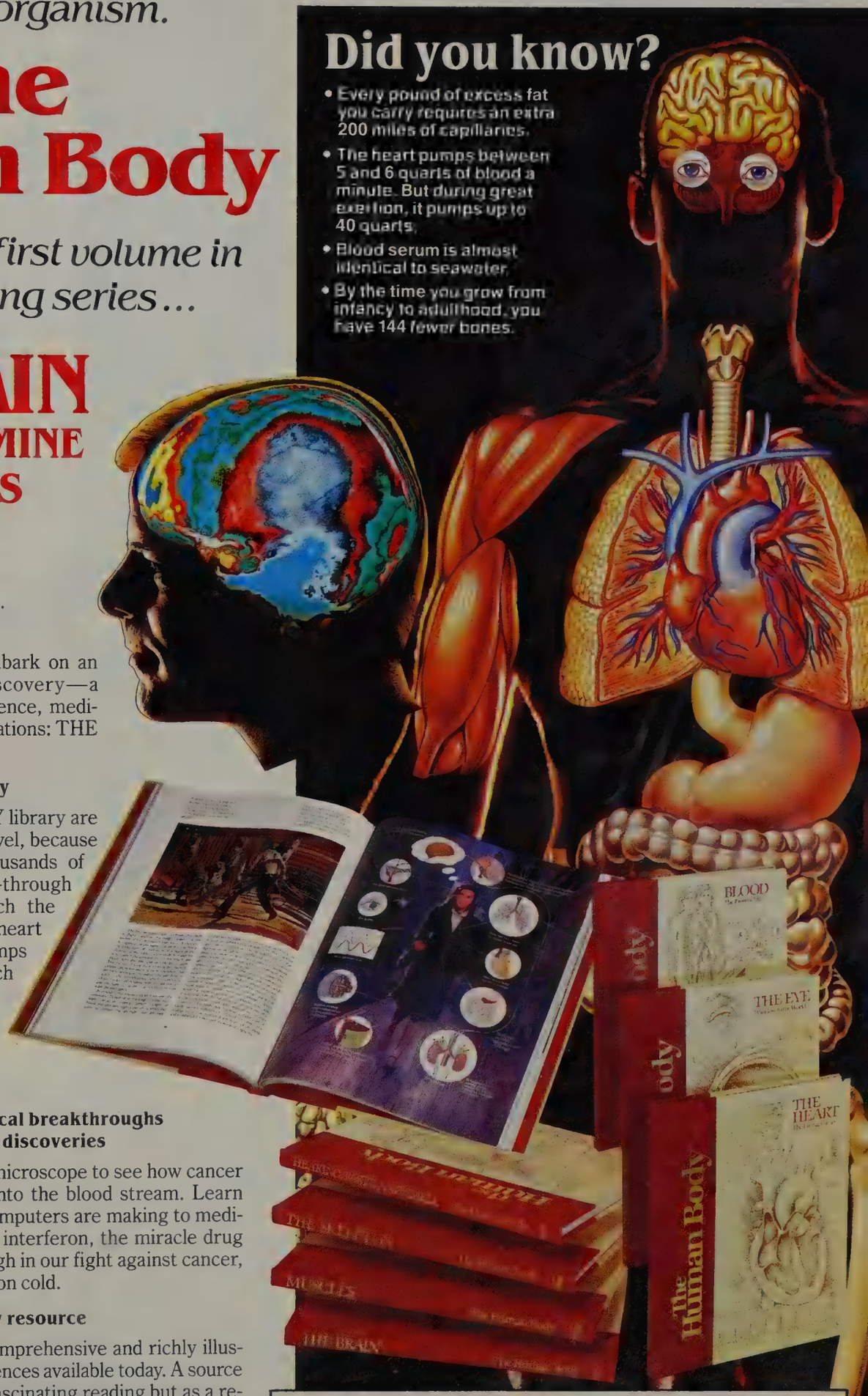

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any standard item in the psychological arsenal of optical illusion—particularly the young, well-dressed lady looking away who becomes the old hag in profile. In fact, any accurately executed picture of a flamingo produces the same jolting effect when viewed upside down (I have checked all historically important portraits)—and for an obvious reason. The jaws have evolved to fit their reversed function. The flamingo's upper jaw does look like a typical bird's lower bill, and we therefore see the upside-down flamingo, not as an absurdity, but as an only slightly odd, swanlike bird.

The morphological alterations go far beyond the changes in external form that produce such a stunning perceptual shif from upright flamingo to inverted "swan." But note first the peculiar curve of the beak itself. The flamingo's bill project out from its face, but then makes a sharp angular turn, producing the pronounced hump that looks like a trough (and works like one) when inverted for feeding. Some Near Eastern peoples call flamingos "cam els of the sea," not because the inclined bil recalls the hump on a camel's back, bu because it mimics the bend of the nose that imparts an inappropriate (but un shakable) impression of haughtiness to both animals (see my essay on the history of Mickey Mouse and the messages acci dentally conveyed by facial features of an

The flamingo from Audubon's Birds of America AMNH

nals, May 1979). Turned upside down, ne hump becomes a grin as a smiling swan" replaces the haughty flamingo.

The bills are elaborately adapted to neir reversed roles, not simply bent in the niddle for proper reorientation. First, relative sizes are rearranged to complement ne shapes. The upper bill is small and nallow, the lower deep and massive. (In nost birds, the smaller lower bill moves up nd down against the larger upper beak.) econd, the flamingo's lower bill (functionlly upper in feeding) has evolved unusual igidity. The bones of each half (or ramus, n technical parlance) are tightly fused, and he rami themselves are then bonded extenively to each other. The lower bill is nassive and well braced. The tongue runs ore and aft in a deep trough cut into the ower jaw. (Remember that filter feeding ets the coordinating theme for all these hanges—the upside-down feeding posure, the attendant alteration in size and hape of the bills, and the fat tongue that nce almost sealed the flamingo's fate.) Third, in most species of flamingo, the maller upper jaw slots into a receiving pace on the larger lower jaw, a reversal of he usual convention—lower jaw moving p and fitting into a larger upper bill.

These complex, coordinated changes nake a persuasive case, but they leave a nissing piece recognized as the key to flaningo peculiarities ever since Menippus ecorded the first-preserved speculation early 300 years before Martial's plea: are novements also reversed to match the inersion of form?

In most birds (and mammals, including umans), the upper jaw fuses rigidly to he skull; chewing, biting, and shouting nove the mobile lower jaw against this table brace. If reversed feeding has conerted the flamingo's upper jaw into a vorking lower jaw in size and shape, then ve must predict that, contrary to all anaomical custom, this upper beak should nove up and down against a rigid lower aw. The flamingo, in short, should feed by aising and lowering its upper jaw.

With great credit to the clear thinking f our finest naturalists, I noted with pleaure in my readings that this central quesion has been continually posed as paranount for more than two thousand ears—by scientists of many cultures and nrough all the vicissitudes of theory and ractice that have marked the history of iology. Georges Buffon, the greatest of ll synoptic naturalists, began his midighteenth century essay on the flamingo y admitting the fame of its red color, vhile maintaining that the odd form of its eak posed a problem of even greater inerest: "This fiery color is not the only

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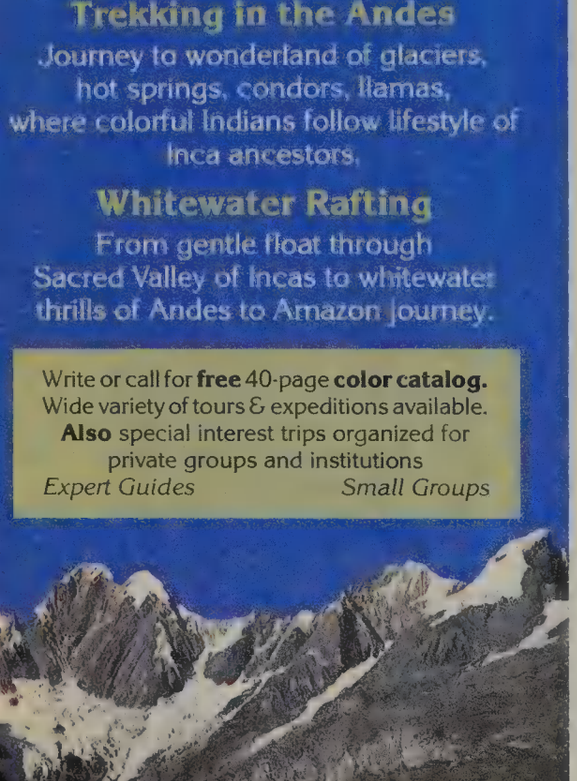

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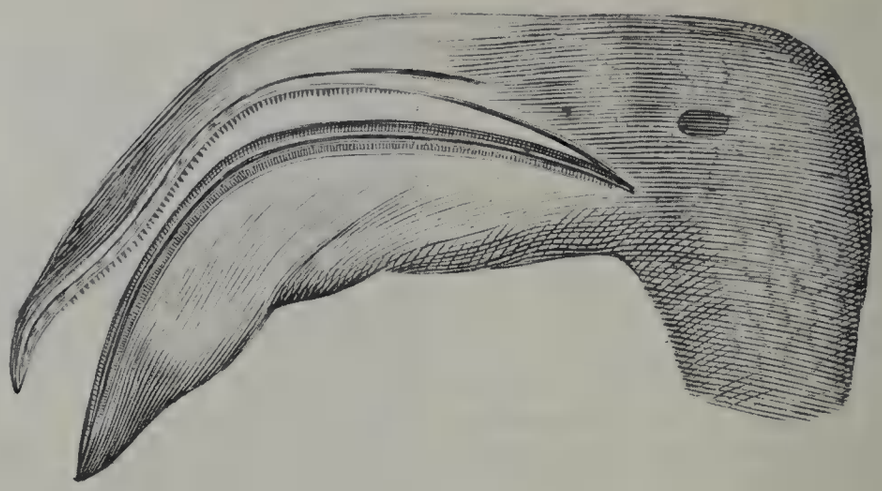

Flamingo, by Nehemiah Grew, 1681

striking character displayed by this bird. Its beak has an extraordinary form, the upper bill flattened and strongly bent at its midpoint, the lower thick and well set, like a large spoon." In short, and in his own lovely tongue—*"une figure d'un beau bizarre et d'une forme distinguée."*

Then, tracing the question right back to Menippus, Buffon states the *primum desideratum* of flamingo studies—"to know if, in this singular beak, it is (as many naturalists have said) the upper part that moves, while the lower remains fixed and motionless." The first extensive and explicit commentary had been offered in 1681 by Nehemiah Grew, the great English naturalist, known primarily for his early microscopical studies of plants. Cataloging the collections of the Royal Society—in his *Musaeum Regalis Societatis or a catalogue and description of the natural and artificial rarities belonging to the Royal Society and preserved at Gresham Colledge, whereunto is subjoyned the comparative anatomy of stomachs and guts*—he encountered a lone flamingo and stated: "that wherein he is most remarkable, is his bill." Grew then suspected that the oddities would all be resolved if the upper beak moved against a stationary lower jaw. He stated that the "shape and bigness of the upper beak (which here, contrary to what it is in all other birds that I have seen, is thinner and far less than the nether) speaks it to be more fit for motion and to make the appulse and the nether to receive it."

The question was not fully resolved until Jenkin published her comprehensive paper in 1957, affirming with hard data the suspicions and good judgment of Menippus, Grew, and Buffon. In fact, flamingos have developed a highly mobile ball and socket joint between upper and lower jaws. The beaks therefore have unusual mobility, and each can move independently. In preening, either the upper or lower jaw may be opened and operat against the other. But, in feeding, the u per jaw usually drops and raises agains stationary lower jaw—just as the gr naturalists had always expected.

The correspondence is complete— form *and* motion. The shapes are ov turned by bending, the sizes reversed, t slotting inverted, the buttressing tra posed. The action, too, is topsy-turvy. peculiar reversal in behavior has eng dered a complex inversion of form. Evo tion as adaptation to particular modes life—Darwin's vision—gains streng from an extreme test imposed by life tirely upside down.

But do flamingos just provide a fun example or do they symbolize a gener ity? What about other animals that l upside down? Consider another animal shallow West Indian waters, the invert jellyfish, *Cassiopeia xamachana* (the orthodox trivial name honors the Nat American designation for the island of maica).

Cassiopeia is an unconventional jel fish in many ways. It grows neither m ginal tentacles nor central mouth. Instea eight fleshy and complexly branch "oral arms" (so called because each c tains a separate mouth) emerge from short and stout central stalk, itself tached to a usual jellyfish umbrella wit difference. The oral arms are cramm with symbiotic algal cells, a possible ada tive impetus for their elaborate branchi (to provide light-capturing surface the photosynthetic symbionts). Each o arm harbors about forty oral vesicles hollow sacs connected with the feedi canals and containing bags of nema cysts, or stinging cells, at their tips. T vesicles shoot their nematocysts at pr (mostly small crustaceans) in strings mucus; the strings with their attached a paralyzed victims are then pulled into t oral mouths. (Yes, I was as amused

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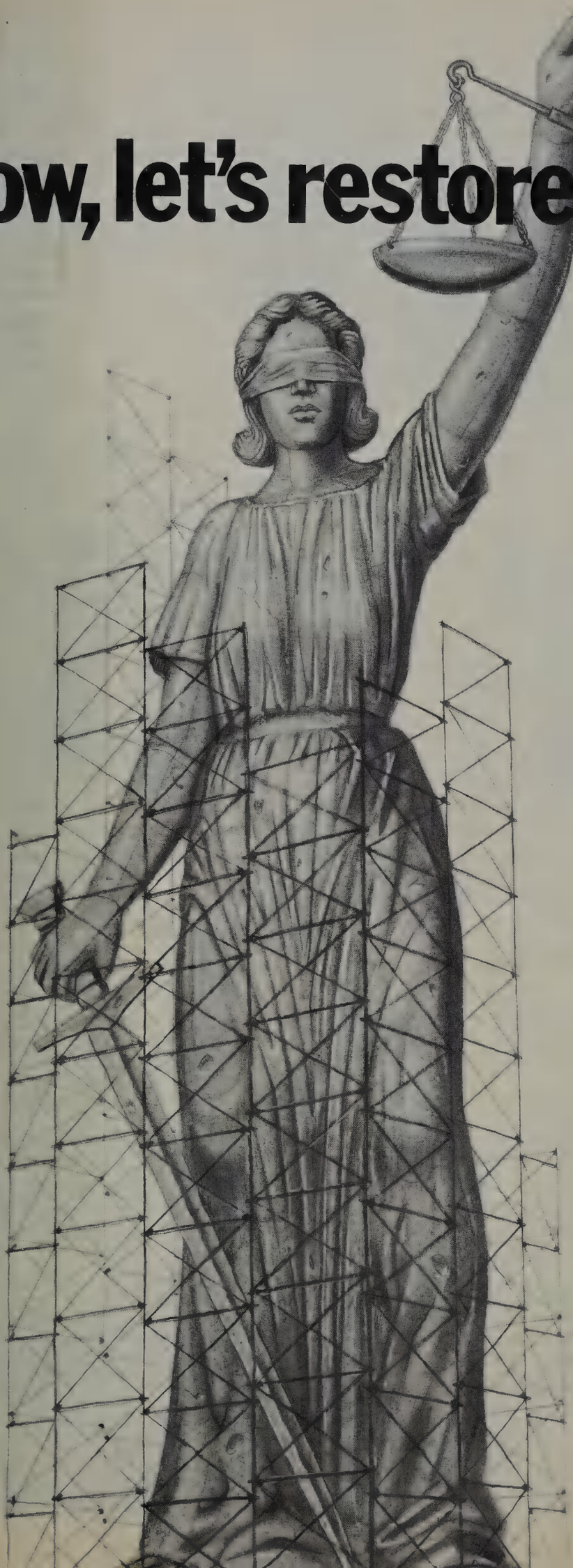

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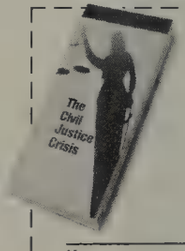

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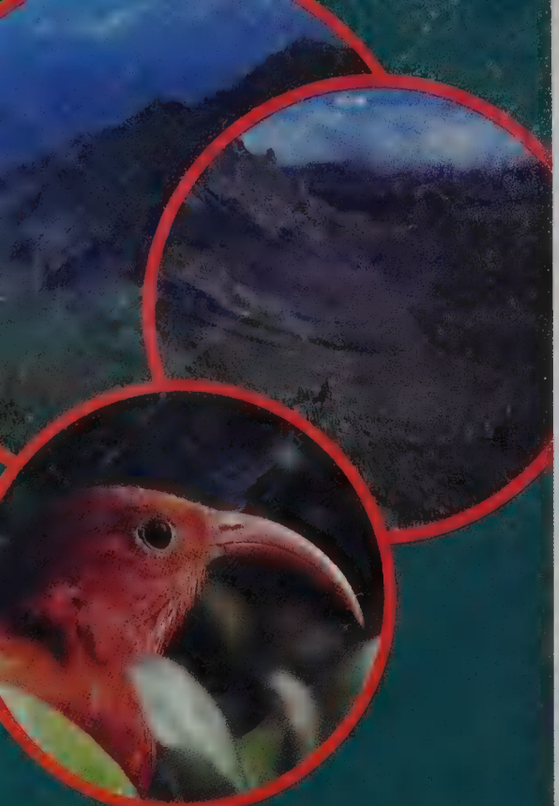

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some of you by the redundant "oral mouth"—the zoological equivalent of pizza pie or AC current. This clumsy phrase arises as unfelicitous fallout from a prior decision to call the appendages "oral arms"—as a shortcut for "mouths of the oral arms.")

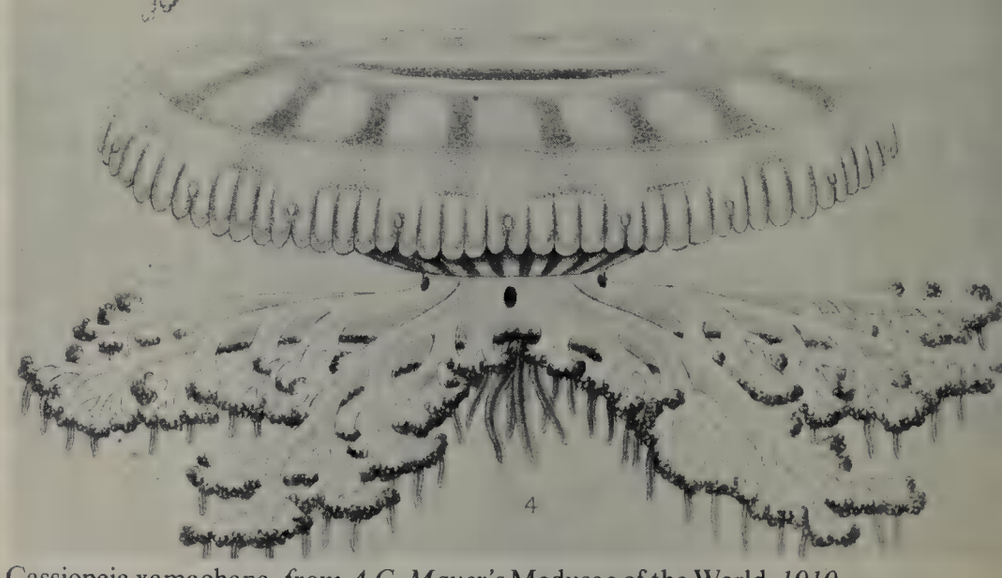
Cassiopeia's unusual anatomy matches its unconventional orientation and style of life. Ordinary, self-respecting jellyfish swim actively with their umbrellas uppermost and their arms and tentacles below. *Cassiopeia* lies stationary on the bottom of shallow ponds and coastal areas—upside down. The top of its umbrella hugs the sediment and the oral arms wave above, waiting for small crustaceans to enter their orbit. Sailors at Fort Jefferson in the Tortugas, where *Cassiopeia* lined the docks, called them "moss cakes." (Since *Cassiopeia* can give a nasty sting, and since men in blue usually spice their language to match the stimulus, I wonder what the sailors really called them. But H.F. Perkins, writing in 1908 on the anatomy of *Cassiopeia*, didn't tell us.)

The umbrella of *Cassiopeia* recalls the flamingo's jaw in its adaptation to reversed life. The umbrella of ordinary jellyfish has a smoothly convex upper surface, as hydrodynamic efficiency dictates. But the upper surface of *Cassiopeia*'s umbrella (its functional lower surface for life upside down) is markedly *concave*—well suited to serve as a cupping device for gripping and holding the substrate.

Cassiopeia has made a second intriguing change for its unusual reversed life. Most jellyfish move through the water by contracting rings of concentric muscles that circle the outer portion of the umbrella. In *Cassiopeia*, one of these muscle rings has been raised and accentuated, forming a continuous circular band surrounding the inner concavity. This raised rim operates together with the concave surface to form an efficient suction cu that keeps the "head" of this jellyfish in it proper position on the bottom. (*Cassio peia* can still swim, albeit weakly and ine ficiently, in the conventional manner. dislodged from the bottom, it will tur over and swim for a few pulsations befor settling down again.) Some scientists hav also suggested that the pulsating contrac tions of the concentric muscles, ordinaril used in swimming, serve other importan functions in *Cassiopeia*'s attached, up side-down position—maintaining connec tion with the substrate by pushing the an mal down and moving water currents wit potential prey toward the oral arms. Bu these reasonable proposals have not bee properly tested.

Thus, flamingos and *Cassiopeia*, tw animals that could scarcely differ more i design and evolutionary history, share th common feature of feeding upside down As a general message amidst the particu lars, they have both redesigned conven tional anatomy to match reversed life style The flamingo's upper bill has change radically in size, shape, and motion to loo and work like the lower beak of most birds The structural top of *Cassiopeia*'s um brella has inverted its shape, all the bette to work properly as an ecological bottom

Adaptation has a wonderful power to a ter an anatomical design, widespread an stable among thousands of species, for th reversed requirements of an odd life styl assumed by one or a few aberrant forms Yet we should not conclude that such Dar winian adaptation to local environment has unconstrained power to design theo retically optimum shapes for all situa tions. Natural selection, as a historica process, can only work with material avai able—in these cases the conventional de signs evolved for ordinary life. The resul ing imperfections and odd solutions cobbled together from parts on hand



Cassiopeia xamachana, *from A.G. Mayer's* Medusae of the World, *1910*

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record a process that unfolds in time fro unsuited antecedents, not the work of perfect architect creating *ab nihilo*. *Ca siopeia* co-opts a band of muscles orc narily used in swimming and forms raised rim to grasp the substrate. Flami gos bend their bill in a curious hump as th only topological solution to a new orient tion.

These adaptations to life upside dow are not just funny facts. They help us comprehend the solution to a major ar classical dilemma of evolutionary theo (hence my decision to unite them in th essay). We can easily understand how fl mingos and *Cassiopeia* work; their u usual features do fit them for their unco ventional lives. But how do these oc structures arise if evolution must proce through intermediate steps? (No one w seriously suggest that the first prot flamingo, turning its head upside dow then produced offspring with a comple set of complex adaptations to reverse life.)

In pre-Darwinian years of the earl nineteenth century, when evolution wa new, and when early exponents of this ra ical idea were trying to work out its ram fying implications, two schools emerge and carried out an interesting (and large forgotten) struggle until Darwin resolve their debate. All admitted the good that usually exists between form and fun tion—adaptation in its static, nonhisto cal meaning. Structuralists, like Etienn Geoffroy Saint-Hilaire, argued that for must change first and then find its fun tion. Functionalists, like Jean Baptiste L marck, held that organisms must fir adopt a different mode of life to trigg some sort of pressure for a subsequent altered form.

The nature of this "pressure" inspire another famous (and better remembere but no more important) debate. Lamarc held that organisms responded creative to the needs imposed by their enviro ments and then passed the changes d rectly to offspring—"inheritance of a quired characters" in the usual jargo Darwin argued that environments do n impose their adaptive pressures directl Rather, those organisms fortuitously var ing in directions better suited to local env ronments leave more surviving offsprin by a process of natural selection.

Since Darwin won this argument abou the nature of signals that pass from env ronment to organism, Lamarck has bee eclipsed and still, despite many efforts b historians to set the record straight, su fers from an imposed reputation as a los not worth taking seriously for any of h ideas.

But Lamarck had the right answer (the me as Darwin's) to the larger dispute be- den structuralists and functionalists. le only proposed the wrong mechanism r how environment gets its message to ganisms.) Geoffroy's structuralist solu- on contains an obvious (and probably fa- lly unresolvable) dilemma. If structure anges first, according to unknown "laws form," and then finds the environment st suited its altered state, then how can ecise adaptation arise? We might allow at some very basic and general change uld precede any functional meaning or lvantage—an animal might, for exam- e, get larger and then exploit the inher- it advantages of increased size. But can e seriously believe that something so mplex, so multifarious, and so inti- ately suited for an unusual ecology as ie flamingo's bill might arise before the ct and without relationship to its useful- ess—permitting the flamingo to discover ly later how nicely such a beak worked pside down?

Lamarck's functionalist solution has an egant simplicity accepted by nearly all volutionists today (but usually attributed Darwin, who also supported it. How- ver much I revere Darwin, I want to ad- ance a plea for recognizing this basic rinciple as Lamarck's primary contribu- on. It does not appear as an incidental otnote in Lamarck's *Philosophie zoo- gique* of 1809, but as a central theme of is book. Lamarck knew exactly what he as arguing and why). Lamarck simply cognized that change of behavior must recede alteration of form. An organism nters a new environment with its old form uited to other styles of life. This behav- ral innovation establishes a discordance etween new function and inherited rm—an impetus to change (by creative sponse and direct inheritance for La- arck, by natural selection for Darwin). he protoflamingo first inverts its normal ill—and it doesn't work very well. The roto-*Cassiopeia* turns over, but its con- ex umbrella doesn't clutch the substrate. amarck wrote:

> is not the shape either of the body or its arts, which gives rise to the habits of ani- als and their mode of life; but it is, on the ontrary, the habits, mode of life, and all ie other influences of the environment, hich have in course of time built up the iape of the body and of the parts of ani- als.

The direct evidence for Lamarck's solu- on cannot emerge from such "com- leted" adaptations as the flamingo's eak or *Cassiopeia*'s umbrella—though ie inference even here becomes quite ompelling (for why should flamingos,

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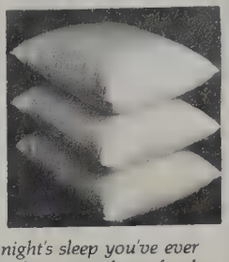

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uniquely among birds, develop such a pe culiar beak if not to exploit their chose odd environment). We must catch the pr cess at its beginning stages—by findin upside-down animals that have already a tered their behavior but not their form.

African catfishes of the famil Mochokidae, for example, include severa species that characteristically swim up side down. Behavior has already change radically, and we have even obtained goo hints about the triggers in some case (*Synodontis nigriventris*, for example eats algae by grazing the undersides o leaves on water-dwelling plants.) But form has altered scarcely, if at all. A few specie have reversed the usual pattern of crypti coloration for fish swimming near the su face. The light bellies of most fish rende them invisible to predators looking u through the water into sunlight above. Bu *S. nigriventris*, as its name (black belly implies, is dark on its anatomical unde side and light on its structural top. Sinc this fish swims upside down, the light sid lies below, as usual. Yet, beyond thi switch in color, most upside-down mocho kids look just like their upright relatives Size, shape, and position of fins have no changed. The trigger (presumably recent is behavioral. We shall wait to see wha changes in form might still ensue.

As a final point, readers might acknow edge my argument but dismiss the exam ples as trivial or peripheral. We all lov flamingos, and *Cassiopeia* might pric our interest (our bodies too, if we get in th way). Mochokids are amusing in aquaria But can we view life upside down as an more than a funny little corner of natura history? All my examples are dead-end ad aptations of a few species; can turning up side down lead to anything fundamenta and expansive?

As an important illustration from his tory (though almost surely an incorrec idea), life upside down once compelled at tention as a leading speculation for th origin of vertebrates—the "worm tha turned" theory, so to speak. Annelids an arthropods, the most complex of seg mented invertebrates, develop ventra (bottom) nerve cords; the esophagu pierces the nerve cords and connects a even more ventral mouth to a central al mentary (gut) canal lying above the nerv cords. In vertebrates, the major nerve cor runs fore and aft in a dorsal (top) position and the alimentary canal, includin mouth and esophagus, lies entirely below

These two designs seem quite in compatible and unrelated. But, and ironi cally in the context of my contrast be tween structural and functional views, th greatest of all structuralists, Geoffro

int-Hilaire himself, noted that an anne- turned on its back would look more n a bit like a vertebrate—for the ven- l nerve cord would then become dorsal d lie above the alimentary canal. In ving one problem, others emerge: the uth now lies topmost on the inverted rm. Geoffroy suggested, as an ad hoc ution straining credulity, that the old uth and nerve-piercing esophagus sim- disappeared and that an entirely new ening (the vertebrate mouth) developed low the dorsal nerve cord, connecting ectly with the gut canal and not pierc- the nervous system. (So many other fferences plague the comparison—lack any annelid structure resembling the tocord or gill slits of vertebrates, funda- ental disparities in embryological devel- ment between the two groups, for exam- e—that the worm theory never mmanded general assent, though it re- ained a leading contender for nearly a ntury.)

Geoffroy never intended his compari- n of vertebrate with inverted worm as an olutionary speculation, but only as a uctural comparison to buttress his re- arkable theory that all animals shared a mmon architectural plan. (He also ar- ed that the segments of an insect's ex- nal skeleton matched our internal ver- brae—and that insects literally lived thin their own vertebrae. This compari- n compelled the additional and astonish- conclusion, forthrightly maintained by offroy, that insect legs are vertebrate s.)

Geoffroy also did not advance his com- rison as a functional hypothesis about aptation—he did not argue (as La- arck might have done) that a worm's in- vative behavior (in turning over) trig- red an adaptive pressure for redesign. uite the contrary: he contended, as a ucturalist, that belly and back are eaningless terms of human invention to scribe a superficial orientation utterly thout significance to what really mat- s—abstract structural laws of form and rmitted pathways of change.

Today, we reject Geoffroy's speculation ong with his approach to form and func- n. Life upside down affirms Lamarck's im that substantial change in morphol- y usually arises as a consequence of be- vioral triggers. The famous fourteenth- ntury motto of that upstart institution, ew College, Oxford, seems to embody essential truth about history as well as nduct: Manners Makyth Man.

ephen Jay Gould teaches biology, geol- y, and the history of science at Harvard niversity.

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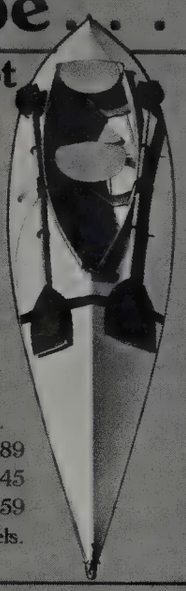

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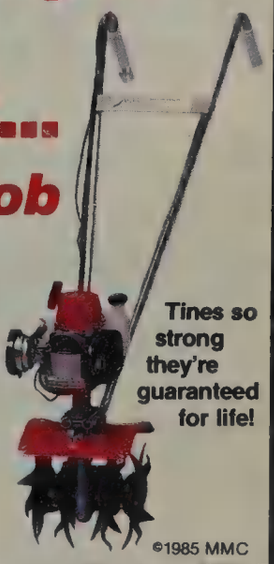

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Superheroes in the Doll Corner

Play patterns and fantasies help young children define themselves as boys or girls

by Vivian Gussin Paley

Kindergarten is a triumph of sexual self-stereotyping. No amount of adult subterfuge or propaganda deflects the five-year-old's passion for segregation by sex. Children of this age think they have invented the differences between boys and girls and, as with any new invention, must prove that it works. The doll corner is often the best place to collect evidence. It is not simply a place to play; it is a stronghold against ambiguity.

When the children separate by sex, I, the teacher, am more often on the girls' side. We move at the same pace and reach for the same activities, while the boys barricade themselves in the blocks, periodically making forays into female territory.

The boys have been trying to leave the doll corner since they came to kindergarten. They are superheroes now—or feel they should be. The girls do not object to superheroes or robbers in the doll corner as long as they play the way girls play.

Domestic play looks remarkably alike for both sexes at age three. Costumes representing male and female roles are casually exchanged. Everyone cooks and eats pretend food together. Mother, father, and baby are the primary actors, but identities shift and the participants seldom keep one another informed. Policemen sweep the floor and dress the baby, and mothers put men's vests over negligees while making vague appointments on the telephone. If asked, a boy will likely say he is the father, but if he were to say mother, it would cause little concern. It can be a peaceful place, the three-year-olds' doll corner, even if monsters and superheroes enter, for the cooking and dressing and telephoning are usually private affairs.

By the age of four, the players are more inclined to tell one another who they are and what they are doing. They want to coordinate themes, but it is not always possible because the boys are beginning to rebel. The girls prefer one mother, one father, and one baby per household and will play auxiliary parts when necessary: sisters, pets, grandmothers, teen-agers, and baby sitters. They would like the boys to be plumbers, carpenters, and firemen, but some boys would rather be monsters or superheroes.

The four-year-old boy is less comfortable in the doll corner than he was the year before; he may occasionally dress up in women's clothes or agree to be daddy, but the superhero clique has formed and the doll corner is becoming a women's room. For their part, four-year-old girls may intermittently exchange domestic roles for Wonderwoman and Supergirl, but the mother and baby roles reign supreme and will continue to do so throughout the kindergarten year.

The atmosphere in the doll corner changes dramatically among five- and six-year-olds. "They are bored," say some adults. "They've had enough doll-corner play." The doll corner, in fact, is entering its final phase, in which girls and boys try to end lingering confusion about the roles they play, roles they will now examine in a predominantly social context.

Although the girls officiate in the doll corner, the presence or absence of boys determines the character of the play. The more cohesive the boys' group, the mor disruptive is its doll corner play; paradoxically, "good" behavior is most often foun among the least mature boys. As th superhero dominates boys' fantasy pla the girls turn to dramatic plots that elim nate boys and bring in more sisters an princesses.

Boys set the tone and girls follow on pa allel paths. Both seek a new social defin tion for "boy" and "girl." They search e erywhere for clues, hoping to creat separate and final images. Society su plies Barbie dolls and *Star Wars*, but th children invent equally interesting syn bols by themselves.

In the class described, for example, yo hop to get your milk if you are a boy an skip to the paper shelf if you are a gir Boys clap out the rhythm of certain song girls sing louder. Boys draw furniture i side four-story houses; girls put flowers i the doorways of cottages. Boys get tired drawing pictures and begin to poke an shove; girls continue to draw. But the in age they are quickest to promote and d fend is separation by fantasy.

The four girls in the doll corner have a nounced who they are: Mother, Siste Baby, Maid. To begin with, then, the will be cooking and eating, crying an cleaning. Charlotte is the mother becaus she tells the others, she is wearing the si ver shoes. Leadership often goes to th child who is most confident about th meaning of symbols.

Teddy watches the scene as he fills u the number board for the second tim Charlotte returns his stare and says, "Yo can be the father." He inserts the last tw tiles and enters the doll corner.

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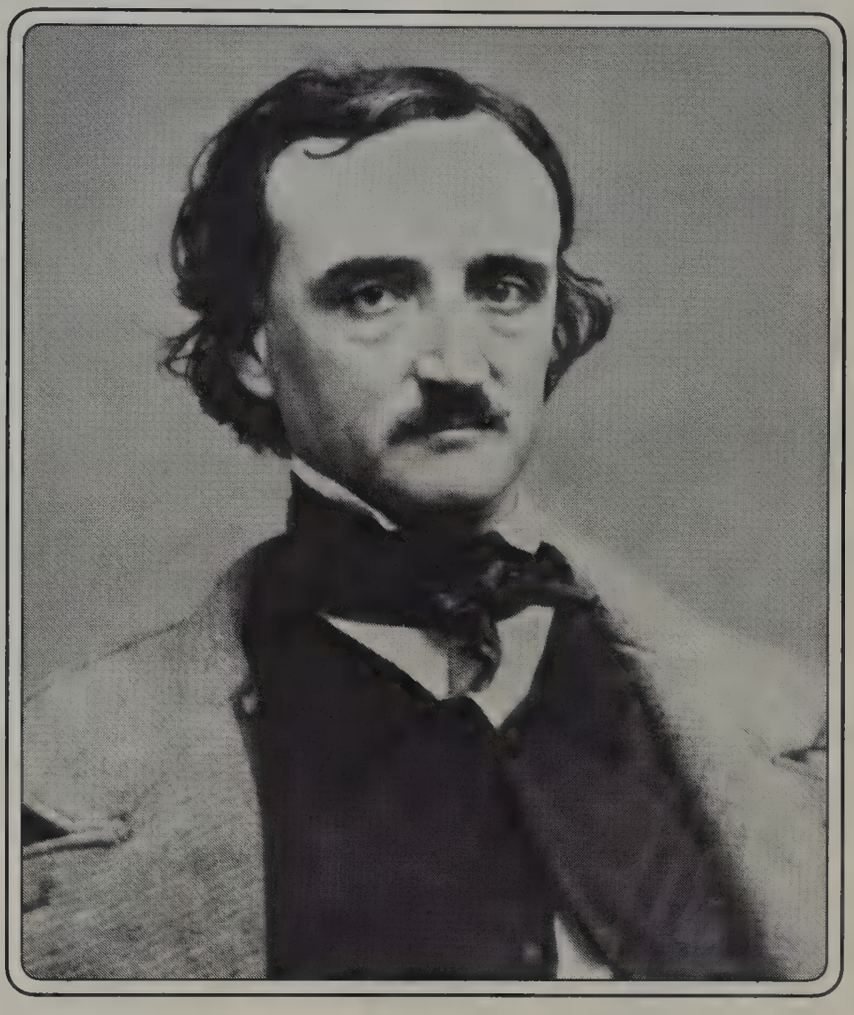

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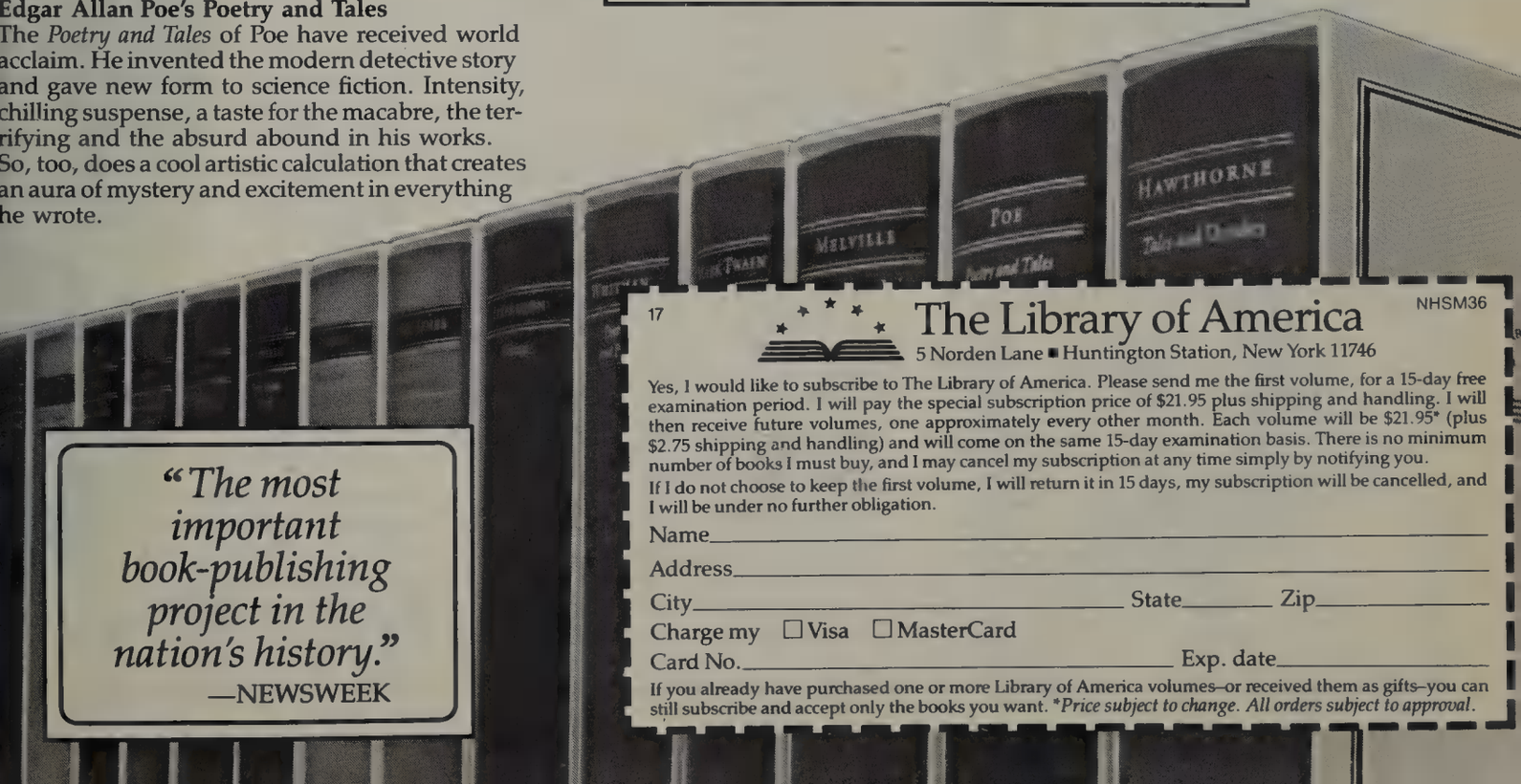

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"Are you the father?" Charlotte asks.

"Yes."

"Put on the red tie." She doesn't know Teddy's name yet, but she can tell him what to wear because she is mother.

The girls look pleased. "I'll get it for you, honey," Janie says in a falsetto voice. She is the maid. "Now, don't that baby look pretty? This is your daddy, baby." Teddy begins to set the table, matching cups and saucers as deliberately as he did the tiles on the number board.

Abruptly the mood changes. Andrew, Jonathan, Jeremy, and Paul rush in, fingers shooting. "We're robbers. Do you got any gold?"

"No," Charlotte says, stirring an empty pot.

Jeremy climbs on the refrigerator and knocks over several cartons of plastic food. "Put up your hands. You're going to jail!"

"We're telling!" The girls stomp out in search of me or my assistant, Mrs. Brandt.

Cops and robbers is off to an early start. The first week of kindergarten is usually uneventful as children cautiously decide what they can expect from one another and from the teacher. They want to know with whom they will play and how free is free play. The four robbers in the doll corner are already a team, having practiced being bad guys in nursery school.

Every year, the girls begin with stories of good little families, while the boys bring us a litany of superheroes and bad guys. This kind of storytelling is an adjunct of play; it follows existing play and introduces new ideas for the future. Language development and creative dramatics may be on my mind, but the children take over the story-plays for a more urgent matter: to inform one another of the preferred images for boys and girls.

Teddy tells his first story at the end of the week. The boys' response is immediate and strong.

"Once upon a time there was this little boy and his name was Pretty. They called him Pretty because he was so pretty. His name was really Hansel. There was this sister. He didn't know he had a sister. The mother and father told him and then they had candy and then they went for a walk."

Andrew, Jonathan, and Paul explode with laughter. "He calls him Pretty!" "Ugh!" "Pre-e-tty!"

"He can call him that if he wants," Charlotte says.

"No he can't!" shouts Andrew. "Not if he's a boy he can't."

Teddy is not insulted, only curious. He smiles at the boys, who continue to make faces. Teddy's use of "pretty" crosses over into female territory, a subject he will learn about from boys, who care mor about boundary lines than do the girls.

"Anyway, his name is Hansel. Just ca him that." Teddy looks at the boys as h speaks.

"Are you sure, Teddy?" I ask.

"Yeah. I'm sure."

The room is quiet. Noise comes in hill and valleys in the kindergarten. Even *Star Wars* drama will eventually win down, the players scattering into gentle pursuits. Calmness follows excitement i natural rhythms, the mood shifting bac into restless gear as increased physical ten sions generate new fantasies.

Andrew runs into the empty doll corne and begins dumping clothes from shelve and hangers on the floor while Frankli watches.

"Y'all playin' house?" Franklin asks.

Andrew looks around quickly, self consciously borrowing Franklin's patois "This gonna be a spaceship. Y'wann play?"

There are six boys in the doll corner. I is the first time they have been there with out girls. Gregory and Ned totter an clump about in high heels, their arm stuck awkwardly into unfastened dresses They giggle and screech and stumble int

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ne other boys, who laugh and pull them own.

Andrew darts questioning glances my way as he surveys the mess: naked dolls ace down under the crib, chairs over-urned, hats and shoes heaped on piles of resses and dishes. There is a moment of tillness, and then Jeremy drags the oven o the middle of the floor.

"This is the computer terminal," he de-lares.

"Put it over here," says Paul. He picks p the fallen chairs and sets them in two traight rows. The oven is now covered by ne shoe rack. Andrew turns two shoes ack and forth and speaks into a silver lipper: "Pilot to crew, pilot to crew, ready or landing. Snow Planet down below."

"Watch out! It exploded!"

"Darth Vader is coming!"

"*Millennium Falcon*, where are you?"

"E-ek! B-e-e-p! Erk! Erk!"

"Get the light sabers!"

Andrew runs to the wood bench. He rabs two long sticks and slams them on ne painting table. "Quick! Emergency! Where's the red paint?"

Mary Ann looks doubtful but hands im her paintbrush.

"Thanks, miss, I won't forget this." He aints a red tip on each stick and rushes ack to the doll corner. "Am I too late?"

"Just in time. Darth Vader found us, ut we got away. Wait, he might be invis-ble." Paul kicks a pile of clothes.

All the while, Franklin has been turning n unseen steering wheel, making a siren ound, and staring through squinty eyes. M-m-m . . . M-m-m . . . Darth Vader, he scapin'! Follow me, men. Ah knows his lan. M-m-m . . . K-k-k . . . P-p-ah-ah! Ah lowed his ship to pieces. He back on the Death Star."

The boys gaze at Franklin in admira-on. Ned repeats Franklin's words softly, o himself: "He back on the Death Star."

The girls don't care what goes on in the oll corner when they are not there. It is ot a place so much as an idea ready to be dapted. Right now the girls are in the lock area building a zoo. They have amed the four rubber lions Mother, Fa-ner, Sister, and Baby and put them in a wo-story house. Girls tame lions by utting them into houses. Boys conquer ouses by sending them into space.

"I wonder, why do you suppose boys ever tell stories about princes and prin-esses?" I ask one day.

"They like rougher games than girls," anie says.

"Couldn't it be a rough prince?"

The girls look surprised. "Princes are ever rough," they answer in unison.

Mary Ann is painting a row of red tu-

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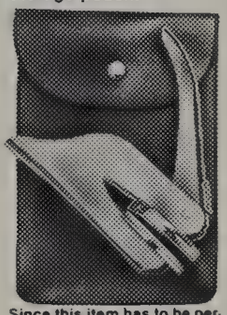

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lips. "Boys don't like to be fancy. Not kings or queens."

Charlotte nods. "Princes are good guys. The boys like bad guys."

"Here's what I think," Charlotte then states definitively. "They don't want to be fancy because girls do. They just like to be not the same as us."

The boys cannot resist a giant anymore than Jack the giant killer can. At our Chinese New Year parade they conquer a fourteen-foot dragon, one of a pair outlined the day before by Franklin. The children want an even larger dragon, long enough for the whole class to carry, but I veto the idea.

"It will be too hard to stay in a single line," I insist. "Two smaller dragons are better."

The morning of the parade, Andrew and Jeremy arrive early and begin to color in one of the dragons. Then Charlotte walks in, glances briefly at what the boys are doing, and runs to the second dragon. Not told which dragon to color, the boys straddle the first dragon while the girls head for its mate. Thirty minutes later, we have a male and a female dragon, one ablaze with *Star Wars* symbols and the other with a dainty flower garden.

The boys take on their dragon's coloration. Red flashes and exploding rockets follow dotted lines until the dragon seems to breathe fire from every jagged point. It shifts and humps along the floor as the boys collide and enter one another's territory, sounding warning cries. Mrs. Brandt and I scurry back and forth, uttering words of caution and applying masking tape to twelve boys and an embattled dragon.

A few feet away, the girls murmur over their brightly petaled flowers. "This is where the godmother stays," Charlotte says, putting Cinderella under a rainbow halo. Soon there are six more Cinderellas surrounded by rainbows and tulips. "Can we paste on tissue flowers?" "Can I use the doilies?" "I'm making valentines."

The boys observe the lady dragon with considerable interest, then plunge back into battle. "Pretend this dragon sees another dragon—"

"Your dragon is done, boys," I say quickly. "I'll put it away until the parade."

Once the dragon is out of sight, the boys go off to other activities, but their play reveals that the dragon has stirred up more excitement than can be channeled into drawings. Mrs. Brandt and I have an attack of second-guessing: We shouldn't have made two dragons; the drago should have been painted red all over; should have organized boy-girl tean Any of these choices might have produc a calmer dragon. Or perhaps not.

In any case, the parade lies ahead. hopes of rehabilitating the dragon, I re a story brought to school by Karen, who Chinese. It is about well-behaved Chine children and smiling, gentle dragons.

"Here's a good idea," I say. "Let's ha each dragon carried by boys and girls gether. Just like this picture in the book

The children stare at me in astonis ment. They have purposely made a b and a girl dragon. Would a boy wear Cinderella costume on Halloween or a g dress up as Darth Vader?

"Okay. I see you don't care for the ide Then I must insist that everyone wa very, very slowly. No bumping or touc ing. No roaring."

The parade route is the long corrid between our room and another kinderga ten class. Our plan seems simple. The bo and girls are to walk in adjacent rov holding the two dragons as if they are o posite sides of one animal: boys on t right; girls on the left. In theory, t dragon will move quietly down the ha way; however, before we reach the first tersection, the boys' dragon rips apart

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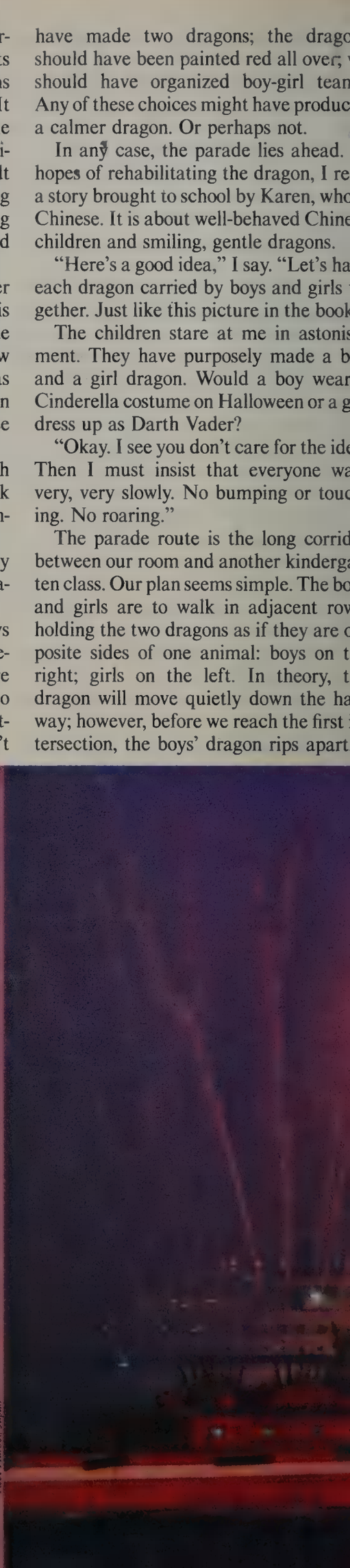


Kobe Harbor, Japan

nd Jonathan back for the mending tape, nd by the time he returns, the dragon has en torn twice more. The girls' side arely flutters as the disfigured dragon rches and groans on its right side.

Mrs. Brandt and I perform quick sur- ery on the dragon, whispering directions. Come on, boys, people are watching. Valk calmly. Stop growling. Breathe eeply."

The more I glare at the boys, the less co- rdinated they become. Heads, arms, and gs are thrust in all directions, jerking and ucking into the dragon, which continues tear. People along the route cannot help ughing as the boys increase their manic ehavior.

Mrs. Brandt and I hurriedly confer. We ave two choices: send the boys back in isgrace or ignore them. One look at them, owever, shows they do not realize they re in disgrace, so we decide to act as if othing unusual is going on.

The march through the other kinder- arten room is brief. "Your dragon is orn," a girl tells us. "On one side," I reply. Ve rush through a Chinese song that re- eats "Good Luck, Happy New Year" hree times and we return to our class. The oys race through the hall waving pieces f the dragon, but Mrs. Brandt and I walk long slowly with the girls, saying nothing.

In the room, the boys have already started to build with blocks. The dragon lies in a heap on the table.

"What did you think of the parade, boys?" I ask.

"Great!"

"Wonderful!"

"We had a great dragon!"

The boys mutilated their dragon and disrupted the parade, yet seem unaware that anything is wrong.

I turn to the girls: "How did you like the parade?"

"Wonderful!"

No one mentions the boys' behavior. Either the girls didn't notice the chaos or else they expect boy dragons to be wild.

"You said we could tape our dragon to the wall," Charlotte says.

"You can. But what about the boys' dragon?"

I put both dragons in the middle of the circle and call everyone to sit down.

TEACHER: The girls want to hang up their dragon.

ANDREW: Ours too.

TEACHER: That's what I want to talk about. Yours is torn.

PAUL: Who did it?

TEACHER: You boys did it.

JONATHAN: It only got torn two times. 'Member when I got the tape?

TEACHER: But no one else touched your dragon. Only you boys.

JEREMY: The other side didn't get torn.

TEACHER: The other side walked slowly.

FRANKLIN: We was too walkin' slow.

ANDREW: Someone came and tore it up.

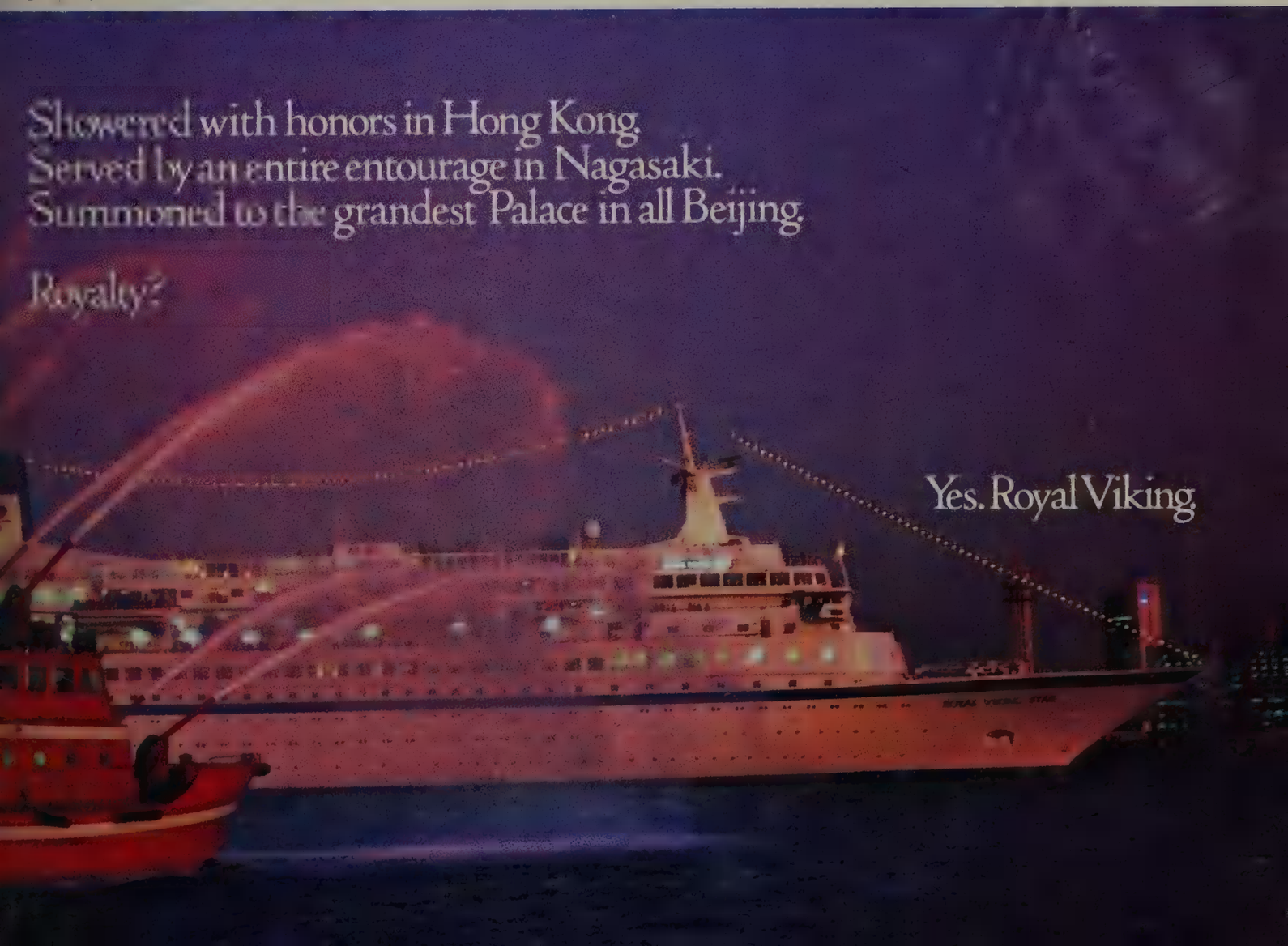
TEACHER: Who? When?

CHARLOTTE: Maybe some kid that doesn't like dragons.

MARY ANN: Some kid that fights with them in the playground.

I decide not to lecture on the events of the parade. The girls remained calm because their fantasies placed them in an enchanted garden, for which they received compliments plus the added bonus of an undamaged dragon. The boys took the dragon as seriously as Jack would have. They confronted it, tricked it, and destroyed it. It is the teacher who does not take dragons seriously, who prefers and expects dragons—and heroes—to remain inside the fairy tale book.

Vivian Gussin Paley has taught elementary school for twenty-five years and is now with the University of Chicago Laboratory Schools, where she was named a Master Teacher. Her two other books are White Teacher *and* Wally's Stories.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A Nest of Dinosaurs

Early in the year 1920, a young mammalogist with the American Museum of Natural History, Roy Chapman Andrews, invited the Museum's president, Henry Fairfield Osborn, to lunch. After lunch, as reported by Andrews in his autobiography, Osborn leaned back in his chair, lit his pipe, and asked, "Well, Roy, what is on your mind?"

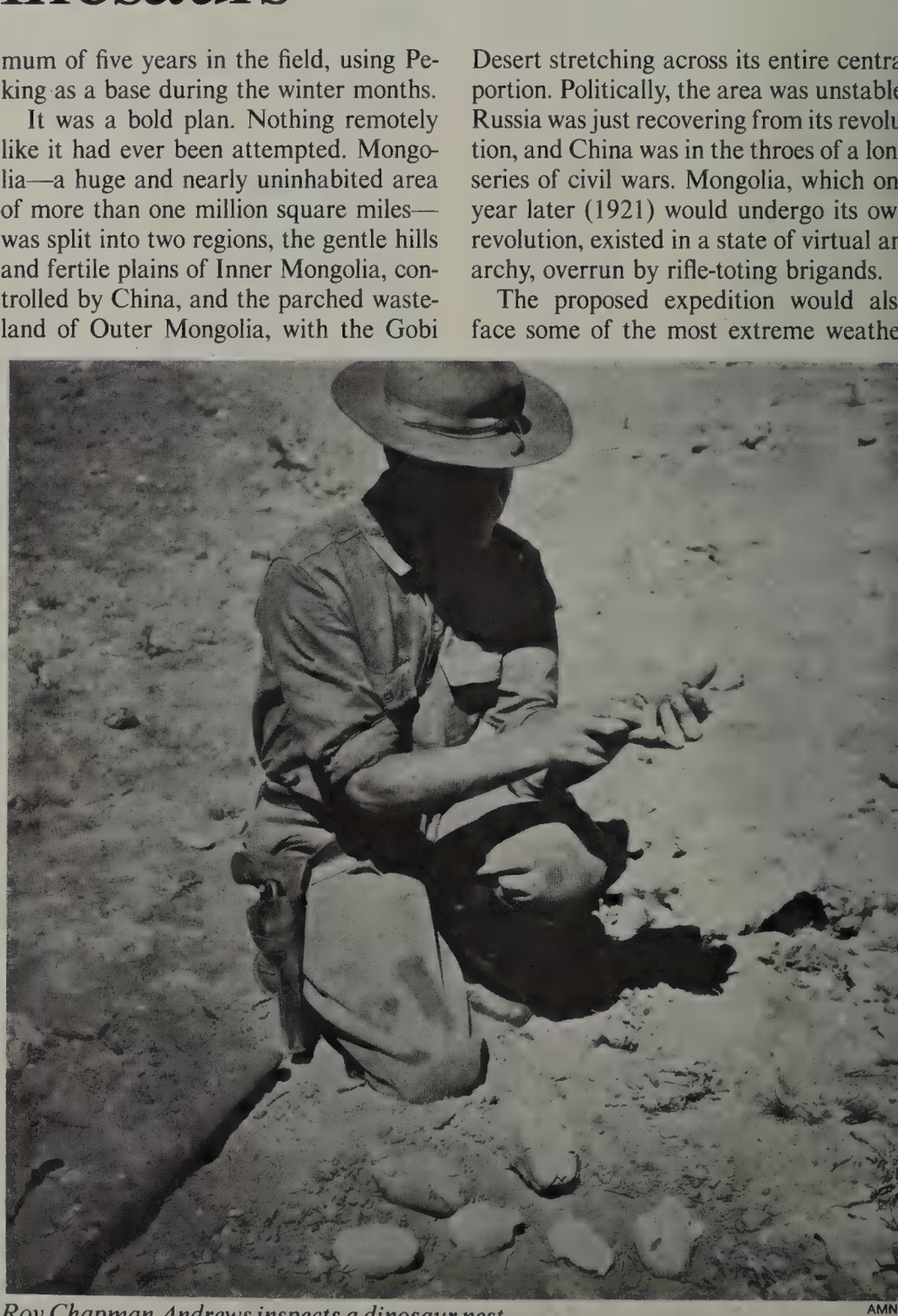
Andrews began to talk about his plan for a new expedition, one that he had been turning over in his mind for eight years. When Andrews had finished, Osborn began asking questions. Finally, he said, "Roy, we've got to do it."

Andrews's grand plan was based on an earlier prediction by Osborn that central Asia would turn out to be the birthplace and dispersal point of the terrestrial life of Asia, Europe, and America—and that the area would yield the fossils of the earliest hominids, the so-called missing link. Andrews wanted to test Osborn's theory with an ambitious expedition. "We should try," he told Osborn, "to reconstruct the whole past history of the central Asian plateau. We ought to learn about its geological structure, fossil life, its past climate and vegetation. We should make collections of its living mammals, birds, fish and reptiles. We should map the unexplored and little-known Gobi Desert."

To do this, Andrews proposed to lead an array of experts—from cartographers to paleontologists—to the heart of Outer Mongolia. As transportation, Andrews proposed a fleet of motorcars, which he felt could cross the level, gravelly sands of Mongolia. A caravan of 125 camels, loaded with gasoline and provisions, would resupply the expedition every 600 or 700 miles. The expedition's dozens of scientists and assistants would spend a minimum of five years in the field, using Peking as a base during the winter months.

It was a bold plan. Nothing remotely like it had ever been attempted. Mongolia—a huge and nearly uninhabited area of more than one million square miles—was split into two regions, the gentle hills and fertile plains of Inner Mongolia, controlled by China, and the parched wasteland of Outer Mongolia, with the Gobi Desert stretching across its entire centra portion. Politically, the area was unstable Russia was just recovering from its revolu tion, and China was in the throes of a lon series of civil wars. Mongolia, which on year later (1921) would undergo its ow revolution, existed in a state of virtual an archy, overrun by rifle-toting brigands.

The proposed expedition would als face some of the most extreme weathe



Roy Chapman Andrews inspects a dinosaur nest. AMN

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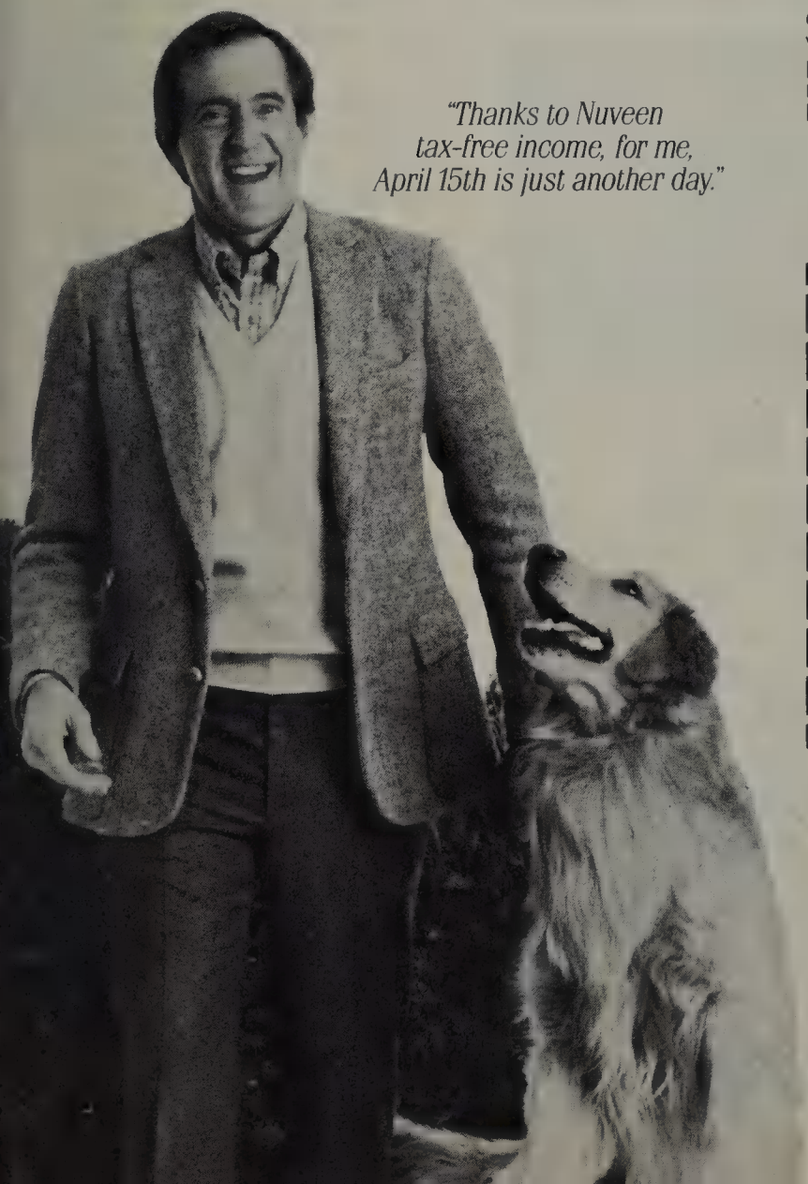

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conditions on the planet. Winter temper tures in Outer Mongolia plummet to 40 50 degrees below zero. Sudden win storms sweep down from the Arctic ar the Siberian steppes and scour the lan scape, and snow usually doesn't melt unt June. Then, in July and August, daytim temperatures soar to 110 degrees in th shade, while nights remain cold.

Physical dangers aside, the greatest ris was that the expedition would fail. Onl one fossil—a rhinoceros tooth—had eve been found in central Asia. Osborn's the ory was based partly on finds in Europ India, and eastern Siberia—forming "ring" around central Asia. Because this, he speculated that early land life ha evolved in Central Asia itself.

Osborn enthusiastically endorsed An drews's plan. Here was a chance to asso ciate the Museum (and himself) with possibly unprecedented scientific disco ery, something that would live forever i the annals of science.

When the Museum announced plan for the expedition, newspapers across th country published the story on their fron pages. What especially caught popular at tention was the mention of a search for th missing link. During the following weeks thousands of telegrams and letters poure into Andrews's office at the Museum most from people seeking a job with th expedition. Offers of assistance cam from every imaginable quarter, includin letters from clairvoyants and young boy looking for adventure.

Shortly before Andrews departed fo Peking in March 1921, to set up his bas and prepare for the first leg of the journey he had one last meeting with Osborn. Th younger man expressed his fears that th expedition would be his "swan song" in ex ploration. "Nonsense, Roy," Osborn re plied. "The fossils are there, I know they are. Go and find them."

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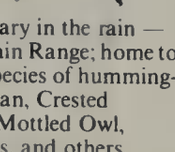

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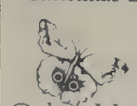

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In April 1922, Andrews and his motorade drove through the gateway of the reat Wall of China and headed out over ıe grasslands of Inner Mongolia. For ıree days the cars slid along a muddy ack, stopping along the way to allow Anrews to explore various outcrops.

On the fourth day, Andrews arrived at ıeir rendezvous point early and set up ımp. In the final expedition report, *The lew Conquest of Central Asia*, he decribed the events that followed. As he rexed in front of his tent, the last two cars the caravan drove rapidly into camp. he men were obviously excited. The exedition paleontologist, Walter Granger, imbed out of the lead car, puffing viontly on his pipe. "Silently," Andrews rote, "he dug into his pockets and proıced a handful of bone fragments; out of is shirt came a rhinoceros tooth, and the arious folds of his upper garments ielded other fossils." Granger laid them ut before Andrews and held out his hand. Well, Roy," he said, "we've done it. The uff is here."

The stuff really was there. As they lunged deeper into Mongolia, they found ıore and more fossil evidence of dinoaurs and early mammals. In the flat esert, most outcrops could be seen miles way, and often all they had to do to disover new fossils was to drive from one utcrop to another.

The expedition continued to unearth ıajor fossils, and Osborn was pleased. Alhough they had not yet located the missg link, they had uncovered traces of anent human camps—some 20,000 years ld—of an unknown people they called ıe Dune Dwellers. Andrews hypothezed that the Dune Dwellers were the abriginal descendants of the earliest umans; he hinted to Osborn that the issing link would turn up at any time.

But on July 13, 1923, the expedition

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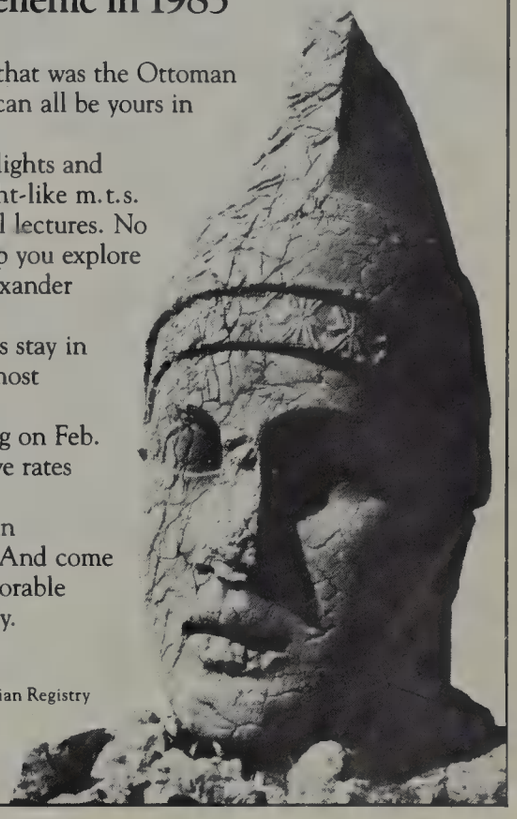

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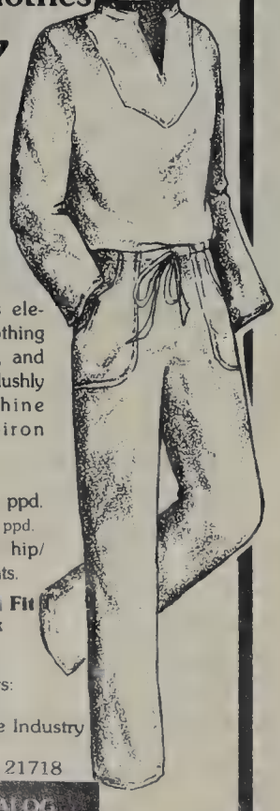

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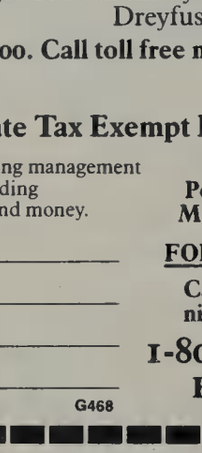

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made a discovery that made everyone forget about the missing missing link. George Olson, a young assistant in paleontology, reported at tea that he had come across some fossil eggs weathering out of the sandstone at the Flaming Cliffs of Shabarakh Usu. Andrews assumed the eggs to be natural sandstone concretions, which could be found almost everywhere. Nevertheless, after tea, Olson led them to his find, where three unmistakable, if broken, eggs lay next to a sandstone ledge, with more bits of shell sticking out of the rock. Could these be dinosaur eggs? No dinosaur eggs had ever been found, and scientists didn't know how dinosaurs bore their young. (While many extant reptiles do lay eggs, some bear live young.) They criticized the conjecture from every viewpoint but finally concluded that the eggs were dinosaurian.

With mounting excitement, they began to brush away the sand from the ledge, exposing more of the remarkably well-preserved fossil eggs. The usual bumps, rugosities, and pores were clearly visible. Solid evidence that these were dinosaurian emerged shortly. Lying on top of the eggs was the fragmentary skeleton of a tiny, toothless dinosaur that, Andrews hypothesized, had been eating the eggs when both beast and nest were covered by sand. More eggs appeared to be encased in the sandstone, and Granger carefully cut a large block of it out of the ledge and shipped it intact to the Museum. Back in New York, paleontologists painstakingly chipped away the remaining rock, revealing a baker's dozen of large, oblong eggs arranged in two concentric circles, just as the dinosaur had laid them millions of years ago.

The expedition dug up dinosaur eggs from a number of species, a very few of which contained fossilized skeletal material. While this discovery brought fresh enthusiasm (and funds), it also brought problems from an unexpected quarter. When Andrews returned to the States the following winter to raise more money for the expedition, he was amazed at popular interest in the eggs. As a fund-raising stunt, he decided to "auction off" an egg. After spirited bidding, Col. Austin Colgate won out with a $5,000 bid (he gave the egg to Colgate University). But when the Chinese and Mongolians heard about the auction, they assumed that their native treasures were enriching the expedition members. This misunderstanding was one of many factors that led to the cancellation of the expedition years later. (The expedition also uncovered tiny mammalian remains in the same strata, which led to the theory that these mammals were

egg eaters and may have been an important factor in the extinction of the dinosaurs—a theory still debated today.)

The dinosaur eggs were only one of many important discoveries made in Mongolia; others were the well-preserved remains of many early mammals and dinosaurs and archeological finds. Although the explorers never found the missing link, they did shed substantial light on the evolution and dispersal of mammals in Asia and filled in gaps in our knowledge of dinosaur diversity.

China's worsening political situation and rising hostility to Westerners forced the cancellation of the 1926 and 1927 expeditions. But Andrews had made up his mind that whatever happened, he was going to make one last try to get into Mongolia in 1928. By spring of 1928, however, conditions on the Mongolian plateau had become very bad. Bandits swarmed over the area in such numbers that everyone who could be robbed had been, and the bandits themselves were starving. Finally, the Chinese government made a truce with the bandits, allowing them to extract specific amounts of "protection money" from traders—$5 per camel and $100 per car. Andrews could only get as far as Inner Mongolia, where he explored a remote area in the northeast. At the end of that year, a group called the Society for the Preservation of Cultural Objects accused the expedition of having "stolen China's priceless treasures" (among them the dinosaur eggs) and denounced its members as "spies against the government" who had been "searching for oil and minerals and smuggling opium." The Chinese authorities at Kalgan seized the expedition's collections, and Andrews spent six weeks negotiating with them to get his crates of fossils back.

In 1929, the Society's onerous demands before it would allow Andrews to undertake a new expedition caused him to abandon his plans for that year. In 1930, Andrews was able to make arrangements with the Society for another trip, and once again he set out to explore Mongolia. This time the expedition made outstanding fossil discoveries, especially of large mammals; among these was an entire graveyard of rare, shovel-tusked mastodon skeletons, previously known only from a few bones. On this trip they had their closest call with bandits, who attacked a lone expedition member. The man drove them off after shooting one in the ear and killing another's horse.

The 1930 expedition was Andrews's last; scientific work in Mongolia had become too difficult and too dangerous. But his influence is evident throughout the

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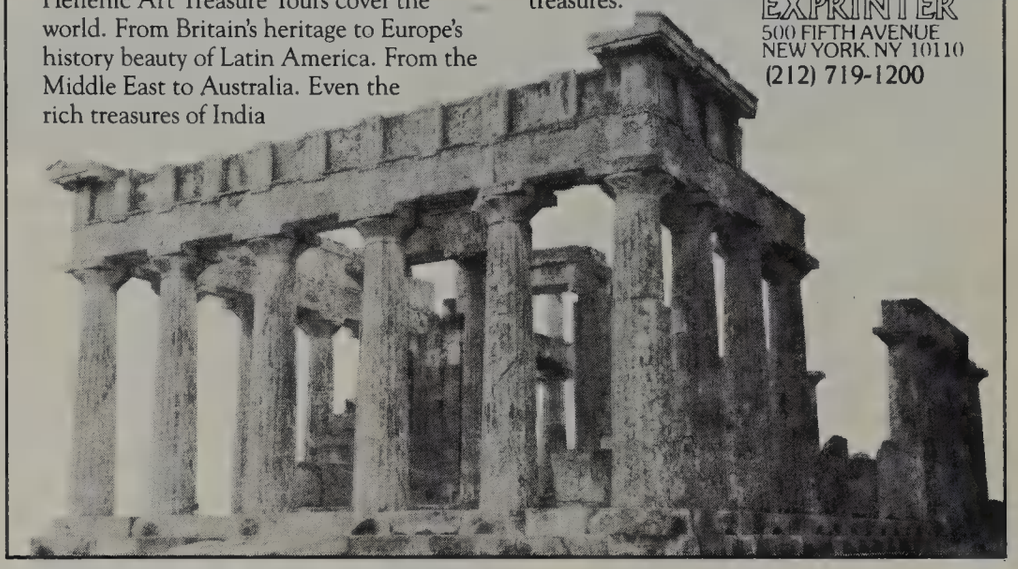

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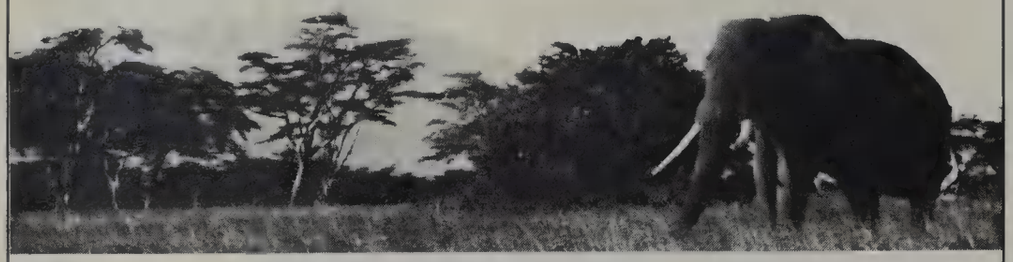

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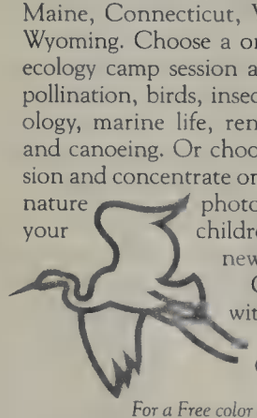

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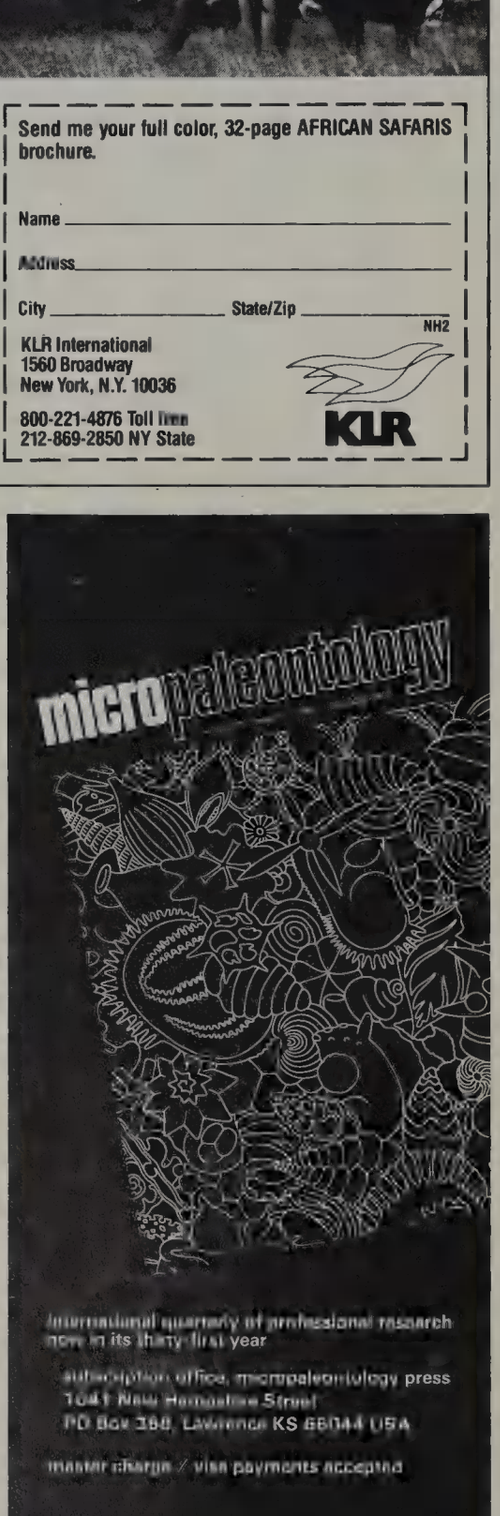
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Musical Tantric Rituals

The harmonic chords and metaphysical texts of Tantric Buddhist rituals were once known only to Tibetan monks. Now Museum members and friends can be the first in this country to hear the Gyuto Tantric Monks, students of the Dalai Lama, in their American première, Wednesday, March 20, at 7:30 P.M. in the Auditorium. A second show will be offered on Thursday, March 21, at 7:30 P.M. in the Hall of Ocean Life.

Since the Chinese invasion of Tibet in 1950, thousands of Tibetans have been living in exile. Among them are the Gyuto monks, who, having left their homeland, feel they can now share certain of their rituals with the uninitiated. The monks' chants generally involve one resonant low note around which others are woven. Many of the notes they sing are well below the bass limit of Western singers, and several monks are capable of singing three-note chords. Some chants are accompanied by sacred instruments.

The program will be narrated by Robert Thurman, a leading American authority on Buddhism. Tickets for the performances are $7.50 for members and students and $12.50 for nonmembers. For information, call (212) 873-1327.

Captured Motion

The grace and precision of animals in motion were remarkably captured by S. Harmsted Chubb in skeletal specimens mounted at the Museum from 1903 to 1949. Many of Chubb's major works will be featured in a new exhibition, *Capture Motion: Skeletal Studies of S. Harmsted Chubb*, which opens in Gallery 1 on Tuesday, March 19. Designed by Ralph Appelbaum Associates, the exhibition includes videos of current research on animal movement. Each of the mounts he created are "doing something," Chubb said in 1949. So with a little imagination, viewers can stand back as a wolf pursues a wild horse or a human reaches for the bridle of another horse.

Shadows of Myth

The shadow play, one of the most ancient forms of theater in existence, combines slapstick comedy with high drama and uses mythical stories from the past to bring to light the current situation of human beings. In a bilingual (English an

epartment. Visitors can find the first di-osaur eggs in a glass case in the Hall of ate Dinosaurs, resting in their nest, 2,000 miles from their original home.

Douglas J. Preston

awi) performance for all ages, the hadow Play Theater Company will resent *Wayang Kulit*, traditional Bali-ese shadow puppetry. *Wayang Kulit* will e performed on Saturday, March 9, at :00 P.M. in the Kaufmann Theater. Ad-nission is free, and further information an be obtained by calling (212) 873-300, ext. 559.

Shadows and Footprints

The sperm whale's social behavior and cology have long been mysteries, but a ew film, *Shadows and Footprints: Great Whales of Sri Lanka*, offers some clues. Narrated by Gregory Peck and with an riginal score by Paul Winter, the film fol-ows scientists at the Indian Ocean Whale Sanctuary near Sri Lanka, as they inter-ct with whales under water. After the creening, staff members of the New Eng-and Aquarium will speak about their tudies of stranded marine mammals and iscuss the significance of whale commu-ication. The program, sponsored by the American Littoral Society, will take place n Wednesday, March 13, at 7:30 P.M. in he Auditorium. Tickets are $6 for Mu-eum members and $7 for nonmembers nd are available by calling the Society at 201) 291-0055.

Latin Music for Children

The group *Alborada Latina* will offer a ampling of Latin American music, from ight-hearted folk music to works of in-riguing complexity, in a program created specially for children. The group's reper-oire includes classical and traditional nusic by Latin American composers such s Heitor Villa-Lobos and Simon Diaz nd classical favorites by Bach, Rossini, nd Poulenc. The free performance will e offered twice, at 2:00 and 4:00 P.M., on Sunday, March 17, in the Kaufmann The-ter. For more information, call (212) 873-1300, ext. 514.

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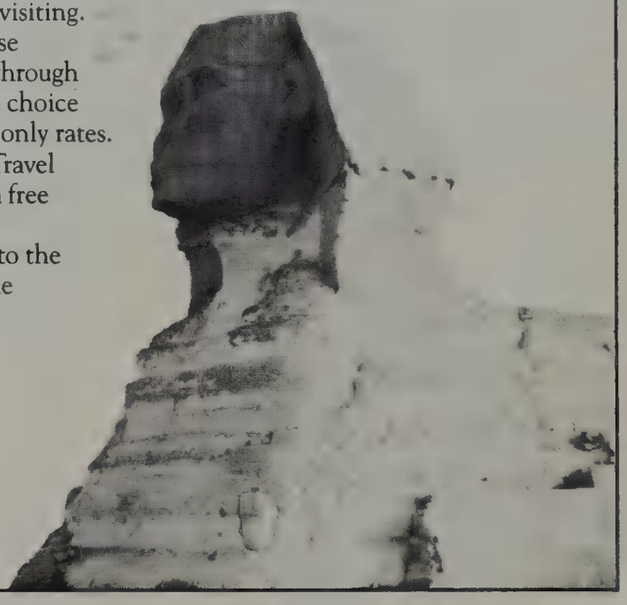

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1893 Paul Gauguin painted a Tahitian woman olding a breadfruit.
rmitage Museum, Leningrad; Tass from Sovfoto

The Great Breadfruit Scheme

l bountiful tree still bears the stigma of its past

y Gerald Oster and Selmaree Oster

Children in the Haitian village where e have a home often approach visitors om the city with the question, "Do you ke breadfruit?" This is a little game they ay to distinguish city people who are ntemptuous of rural life from those who e sympathetic. Although the breadfruit a tasty and nutritious fruit, produced by tree that grows abundantly in the soft, umid soil of tropical lowlands, many Hai-ans hold it in low esteem. Perhaps one eason for this attitude is that the bread-uit is widely used as food for pigs. An-her, more likely reason is that eigh-enth-century colonists introduced the readfruit into the Caribbean area to pro-de food for slaves. In Haiti, which be-ame the first black republic, this infa-ous history may have translated into a eling that the fruit is fit only for pigs and ountry bumpkins.

The breadfruit tree (*Artocarpus altilis*) a seedless plant; grown from root suck-s, it requires some care to propagate. It ems to have originated in the Malay Ar-hipelago, where it has been cultivated nce antiquity. From there people spread to the Polynesian islands. (According to e mythology of the Marquesas Islands, e god Pukuha traveled to the under-orld to fasten a hook to the breadfruit ee, and succeeded in gradually pulling it p.) The tree became so crucial to daily fe in the South Pacific that Polynesians ere unable to conceive of a land where e breadfruit did not exist. Traditionally, olynesians regarded the breadfruit tree ith the same reverence accorded to the ango tree in India. It yields bountiful od and provides welcome shade. It is urdy and not easily damaged by strong inds, an important consideration for a urricane-prone region.

The first detailed description of the breadfruit published in the West appeared in William Dampier's *New Voyage Round the World*, printed in 1697. Dampier was an English explorer of the South Pacific who later became a buccaneer along the Spanish Main. (He also rescued the shipwrecked Scottish sailor Alexander Selkirk, whose adventures provided the basis for Daniel Defoe's novel *Robinson Crusoe*.)

The breadfruit found its champion in the British naturalist Joseph Banks, who accompanied Capt. James Cook on the first (1768–69) of Cook's three scientific expeditions to the Pacific. Banks himself financed the expedition, which enormously expanded the West's knowledge of the flora and fauna of the South Pacific, including Australia. Banks's enterprise, employing appropriate specialists to gather information with a view to possible economic gain, is one of the earliest examples of sponsored scientific research, a commonplace today.

In the course of their travels, Cook and his men were impressed with the voluptuous life of the natives of Tahiti and attributed their good fortune largely to the breadfruit. About the trees, Captain Cook wrote in his journal,

> the Earth almost spontaneously produces [the trees] or at least they are raised with very little labour, [and] in the article of food these people may almost be said to be exempt from the curse of our forefathers [since] scarcely can it be said that they earn their bread with the sweet of their brow, [for] benevolent nature hath not only supply'd them with necessarys but with abundance of superfluities.

Joseph Banks's first impression of Tahiti was of a well-kept park, since the groves of breadfruit trees were so shady that there was no underbrush. At the end of the voyage, Banks met with King George III to discuss the botany of the South Seas, inaugurating an enduring friendship based on their mutual love of gardens. It was Banks who convinced the king that breadfruit would make a cheap food for slaves in the British West Indies.

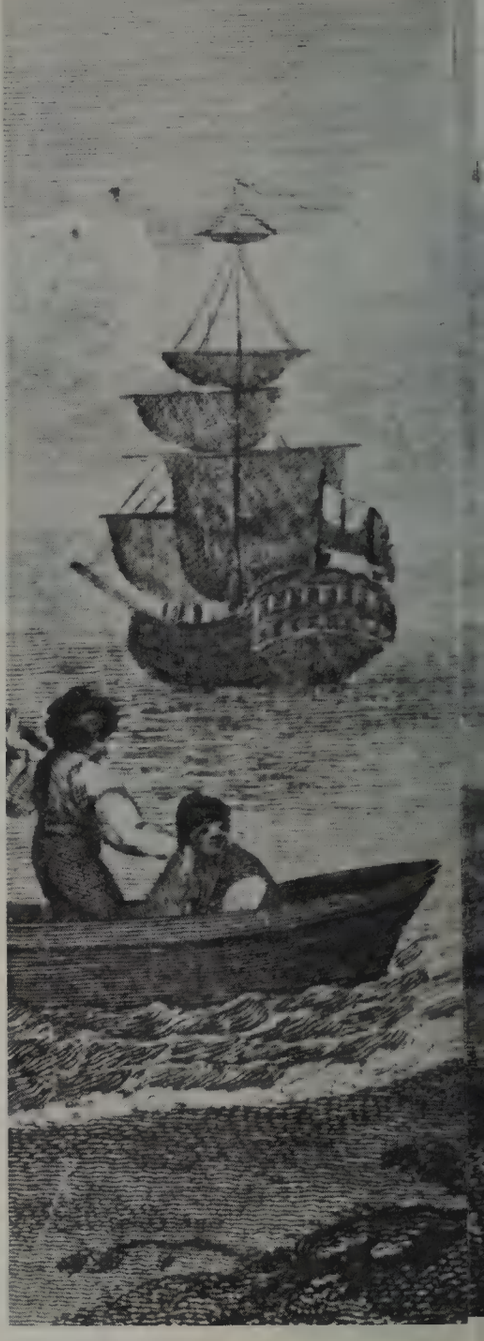
The products of the West Indian colonies, notably sugar, coffee, cocoa, and indigo, were a principal source of revenue for eighteenth-century England. To cultivate these cash crops profitably, slave labor was needed, and a major factor in the colonial economy was the cost of feeding the slaves. Garden space had to be set aside, and slaves needed time off to plant their own food. They were allowed Saturday afternoons, as well as Sundays during off-crop season, to work their own gardens. The English efficiency experts reasoned that breadfruit would be the ideal fuel for the slave machines, or "pieces of the Indies," as the slaves were called when transported from Africa.

Banks's idea was quickly taken up by wealthy British investors, who felt that importing the breadfruit into the colonies would reap even more profits for the slave owners. (Even before any trees were delivered, Banks was being thanked for his efforts by the Jamaican House of Assembly, which consisted mainly of slave owners.) In 1789, George III commissioned Lieut. William Bligh to carry breadfruit trees from Tahiti to the British colonies in the Caribbean. A botanist was assigned to Bligh's ship to carry out Banks's precise written instructions, and under his supervision, some one thousand pots of young breadfruit trees were loaded in Tahiti. Bligh had encountered the breadfruit be-

Library, New York Botanical Garden, Bronx, New York

The seedless breadfruit, below, which probably originated in the Malay Archipelago, was spread by human cultivation throughout the Pacific islands. In the eighteenth century, the British acquired young plants in Tahiti, right, to provide food for slaves in their West Indian colonies.

Robert Frerck; Odyssey Productions



fore, while ship's master on Captain Cook's third (and for Cook, fatal) voyage in 1776–79. Now he commanded his own ship, H.M.S. *Bounty*.

During the long sea voyage, the maintenance of the living cargo proved to be physically taxing, a chore beyond the call of the seamen's normal duties. The thousand plants in their soil-filled wooden casks with gravel drainage bases had to be transferred daily from below decks, where they were kept warm at night, to above deck for sunshine. The breadfruit, being native to the humid tropics, also required copious amounts of water to stay alive. Bligh's efforts to water all of the plants curtailed the crew's supply of drinking water. This, coupled with his overbearing manner toward the men, led to Bligh's downfall. Following the celebrated mutiny, Bligh's precious plants were thrown overboard and he was put in an open boat. After a precarious 4,000-mile trip at sea and his subsequent return to England, the indefatigable Bligh, again at the urging of Banks, returned to Tahiti for a second try. Evidently, Banks still felt that the great breadfruit scheme was vital to the British economy. This time the breadfruit plants must have been well watered because when Bligh's ship *Providence*, with its 1,200 trees, sailed into Port Royal, Jamaica, in 1793, it was described as a floating forest.

But the breadfruit investment scheme was no bonanza. The slaves did not take kindly to the new fruit, preferring the familiar plantain, or cooking banana. (The Spanish had imported the plantain tree into the West Indies in 1500, the same year they initiated the African slave trade to the Caribbean.) In any case, placed there against their will, the slaves probably would have resented any new food proffered by the colonists. (A somewhat analogous situation was the reluctance of Irish Roman Catholic tenant farmers, in 1845, to accept the British offer of maize in place of the potato. The potato crop had been decimated by a fungal disease, but Irish resistance to maize was so extreme that people chose to starve rather than grow it. Also, the Irish could emigrate; slaves did not have that option.)

In Jamaica, although Bligh's trees were propagated (and some of the originals survive in the botanical garden at Kingstown, on the island of Saint Vincent), only pigs ate breadfruit for half a century after the tree's introduction. The breadfruit became acceptable human food only after the emancipation of the slaves in 1838. In Haiti, the breadfruit's introduction is popularly credited to Henri Christophe, a former slave in the British colony of Sa[int] Kitts, who became the king of northe[rn] Haiti in the early nineteenth century. [Sl]

The breadfruit is a starchy food co[m]parable to the plantain in both carboh[y]drate and vitamin B content. But t[he] breadfruit has considerably more fib[er] than the plantain. Soured by long storag[e] the breadfruit also becomes very rich in [vi]tamin C, just like the fermented form [of] cabbage, sauerkraut. In his second vo[y]age, Captain Cook demonstrated that T[a]hitian breadfruit contributed to his men's resistance to scurvy, a disease caused b[y] lack of vitamin C in the diet and th[e] plague of sailors on long voyages. For th[is] contribution to clinical medicine, Coo[k] was awarded the prestigious Copley Medal of the Royal Society of London.

The taste of breadfruit has often bee[n] praised. One of Captain Cook's seamen, quoted in the August 29, 1771, edition of the *London Evening Post*, said tha[t] "breadfruit when baked is superior to an[y] [bread] made with wheat." Alexande[r]

who was of Haitian parentage, de-
ts taste as the crustless part of
ad with a slight suggestion of arti-
d Jerusalem artichoke. Dumas
ly convinced his friend Jules
the wonders of baked breadfruit.
's novel *20,000 Leagues Under*
Captain Nemo orders a break in
ls of the submarine *Nautilus* to
r food on a desert island. The re-
eal is baked breadfruit.
eadfruit is usually picked by be-
ed off the tree before it is ripe,
suitable for cooking. The nearly
fruit is six to eight inches in di-
nd weighs about six pounds. It
en skin and a firm, white pulp.
ly, the breadfruit is prepared like
o or the plantain. Fried, it tastes
ch fried potatoes; boiled, it is
steless, unless eaten with sauces.
erence is for baked breadfruit.
e fruit is put in the coals of a fire
d until the outer skin is charred.
is then peeled and the hot pulp
eaten. The children of our village regard the baking of breadfruit as a major event. They run through the coconut groves seeking fuel for the fire, and the meal itself is a time for the great Haitian pastime of storytelling.

If allowed to ripen, the breadfruit turns brown and the pulp becomes yellowish, mushy, and sweet. As with the banana, the ripening takes place as enzymes convert starches into sugars. Haitian families usually feed ripe breadfruit to their pigs (fallen fruit used to be scavenged by pigs as well, but because of a swine disease, Haiti's freely roaming native pigs have been replaced by penned imported breeds).

In Polynesia, however, the ripened fruit is part of the traditional cuisine. In its sweet form, it may be served uncooked as a baby food. Flavored with lemon juice it tastes vaguely like applesauce. The soft breadfruit is also used in pies and puddings. When preserved for a long period of time, the mushy breadfruit becomes vinegary and is used to spice boiled, firm breadfruit. The Tahitians' method of preserving breadfruit is described by Captain Cook in his journals:

Of bread fruit they make two or three dishes by beating it with a stone pestil till it makes a paste, mixing water or cocoa nut liquor or both with it and adding ripe plantains bananoes Sour paste &c[a], this last is made from bread fruit in the following manner. This fruit from what I can find remains in season only 8 or 9 months in the year and as it is the chief support of the inhabitants a reserve of food must be made for those months when they are without it; to do this the fruit is gather'd when upon the point of ripening, after the rinde is scraped off it is laid in heaps and cover'd close with leaves where it undergoes a fermentation and becomes soft and disagreably sweet, the core is then taken out and the rest of the fruit thrown into a hole dug for that purpose the sides and bottom of which are neatly laid with grass, the whole is cover'd with leaves and heavy stones laid upon them; here it under goes a second fermentation

and becomes sourish in which condition they say it will keep good 10 or 12 Months, as they want to use it they make it into balls which they wrap up in leaves and bake in the same manner as they do the fruit from the tree, it is then ready for eating either hot or cold and hath a sour and disagreable taste. In this last state it will keep good a Month or six Weeks, it is called by them Mahai and they seldom make a meal without some of it one way or another.

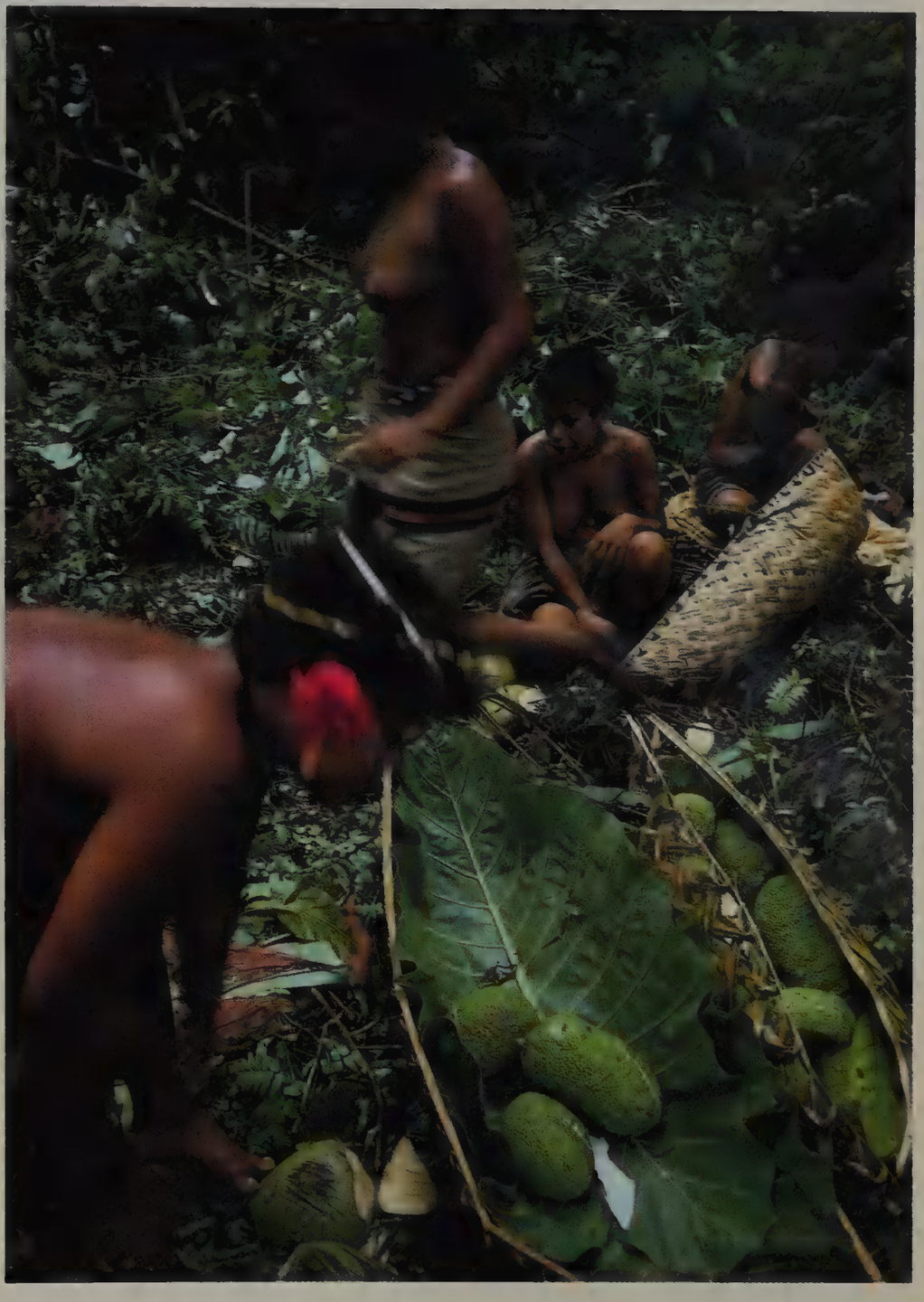
In Tahiti, where the rainy days are spread uniformly throughout the year, fruit from one tree or another is available over long periods. In the Caribbean, however, the breadfruit crop appears twice a year following the most intense rainy months, usually May and October. In season a tree will bear about 500 fruits, which dangle at the tips of the branches like decorative balls on a Christmas tree.

The breadfruit is a good source of ca bohydrates: a single fruit provides 2,70 calories, roughly the minimum daily cal ric requirement for a fieldworker. Hov ever, a diet consisting exclusively breadfruit is incomplete because it lac protein. Protein deficiency is particular acute in the tropics because of the pr dominance of such high-carbohydra foods as taro, manioc, corn, and suga

Nicholas DeVore III; Bruce Coleman, Inc.

In the Caroline Islands of Micronesia, a woman, left, pounds unripened breadfruit for incorporation into a paste. Below: Women gather a variety of breadfruit that has been picked while still green. If allowed to ripen, the starchy flesh of the fruit becomes sweet and, eventually, vinegary.

Nicholas DeVore III; Bruce Coleman, Inc.



Where sugar is plentiful and protein scarce, a mother may give sugary water to her weaning child to satisfy its hunger. Such two- to three-year-olds can develop kwashiorkor, a protein-deficiency disease characterized by sparse, reddening hair and a bloated appearance. These "sugar babies," most commonly seen in times of famine, are severely immunodeficient, easily succumbing to diseases, such as measles, that are not serious for normal children.

One cheap source of protein (and fat as well) available in the tropics is the breadnut, the seeded form of the seedless breadfruit tree. Botanists are divided as to whether the seedless form originated from the seeded form or developed as a hybrid of the seeded form and another seeded species. Despite its importance as a food plant, the breadfruit's botany and classification still have not been fully explored. (Adding to the confusion, the popular terms *breadfruit*, *breadfruit tree*, and *breadnut* also apply to a number of other species of plants.)

Breadnuts, which resemble chestnuts, may be boiled, then peeled, mashed, and sweetened to feed small children. Others eat breadnuts roasted—they taste like

Along with their fruit, breadfruit trees, right, provide shade, leaves for fodder, a latex glue, and other dividends. Opposite: The male catkin, the large leaves, and the globular fruit of the breadfruit tree.

roasted Italian chestnuts. The French brought the breadnut to Haiti and their other Caribbean colonies in 1783, ten years before the seedless breadfruit arrived in Jamaica. But for some reason, the breadnut never became as popular, even though it is easier to cultivate. For Haitians, the breadfruit remains *l'arbre véritable,* "the true tree."

The breadfruit tree provides more than food. Because it bears leaves year-round, it offers ample protection from the intense sunlight of the tropics. The fully grown tree is thirty to sixty feet high, with a spread of about half its height. The dark green leaves, which make excellent cattle fodder, are one to three feet long and of a shape and texture very much like that of the fig tree, which is in the same family. When in bloom the breadfruit tree is particularly handsome. Bark cloth can be made from the inner bark of the tree's young branches, and its viscid, milky latex, which hardens on exposure to air, is a convenient glue. One exotic use for the latex is to put it on tree branches to capture birds. A ball of cotton soaked in it makes a caulking compound for boats. The latex of the breadfruit tree also makes an excellent medicinal plaster and has been used in the treatment of thrush, an oral fungus disease of newborns. Dried latex is a popular chewing gum in the tropics.

Despite the breadfruit tree's bounty, groves are fast disappearing from the tropical landscape. Breadfruit is being replaced by sugar cane and banana, both of which grow well under the same conditions. These cash crops figure prominently in the gross national product of developing countries, while locally consumed breadfruit gets scant recognition from economists. Haitian farmers prefer to grow bananas because the plant is continuously productive. At any given time, one or another plant in a banana grove provides fruit for household consumption or sale. The seasonal supply of breadfruit, on the other hand, is too great for kitchen needs, and the sale price is ridiculously low. Even picked in its green stage, the fruit can last for only three days without refrigeration.

At present, demand abroad is too low for the excess breadfruit crop to be exported like the banana. The fresh breadfruit occasionally seen in some fruit markets in the United States (such as the Hispanic market under the railroad viaduct uptown in New York City), is flown in from the Caribbean. (Attempts to grow breadfruit in southern Florida have not met with success, apparently because of occasional damaging frost and the less humid climate.) An excellent flour can be made from the breadfruit, but so far no one has produced it commercially so that it might be exported.

The trend away from breadfruit is unfortunate. Although bananas are among the most prolific of food crops (yielding, per area cultivated, forty times as much carbohydrate as the potato), the breadfruit tree is still more productive. A well-watered tree bearing twice a year yields about 1,000 breadfruits, each weighing about six pounds. The tree may occupy an area of about 800 square feet. The same land surface could accommodate sixteen banana trees, each yielding annually one banana stalk of 50 pounds, a total of only 800 pounds.

In order to be profitable, bananas and especially sugar cane must be grown in large areas. Perhaps a niche can be found for the breadfruit in scattered corners of the tropical landscape, even in urban backyards. Despite association with a negative past, both the seedless and seeded forms of *Artocarpus altilis* deserve to enjoy a renaissance. As Joseph Banks wrote, "If a man should in the course of his lifetime plant 10 such trees which if well done might take the labour of an hour or thereabouts he would as compleatly fulfill his duty to his own as well as future generations." □

Mary Grierson: Na Lima Kokua, Pacific Tropical Botanical Garden

Caterpillars are the food of choice for chickadee nestlings, fledglings, and nesting adults. Wintering birds eat berries and conifer seeds and inspect twigs and bark for animal foods such as insect eggs and pupae.
Irene Sacilotto

The Tiniest Established Permanent Floater Crap Game in the Northeast

Unattached black-capped chickadees roam among regular flocks, waiting for a lucky break

by Susan M. Smith

All winter long, black-capped chickadees have been among the most common visitors at bird feeders over much of the Northeast. Now, as spring arrives, these familiar little birds usually disappear from the feeders, almost as though they have left the area.

Actually, these chickadees are year-round residents over most of their range. The birds don't leave their winter neighborhoods, but abandon the feeders as they switch diets to their more natural fare of caterpillars and other insect food. At the same time, they adopt a different social organization. They are preparing for the breeding of the next generation, the crucial act of survival for all species. In the coming months the successful ones will be frantically feeding clutches of five to nine nestlings—extending the black-capped chickadee lifeline into the uncertain future.

Studying chickadees is addictive—I've been hooked on them for years. My current study, begun in 1979, involves banding as many local chickadees as possible each fall with unique combinations of colored plastic leg bands. This allows me to tell individuals apart at a glance.

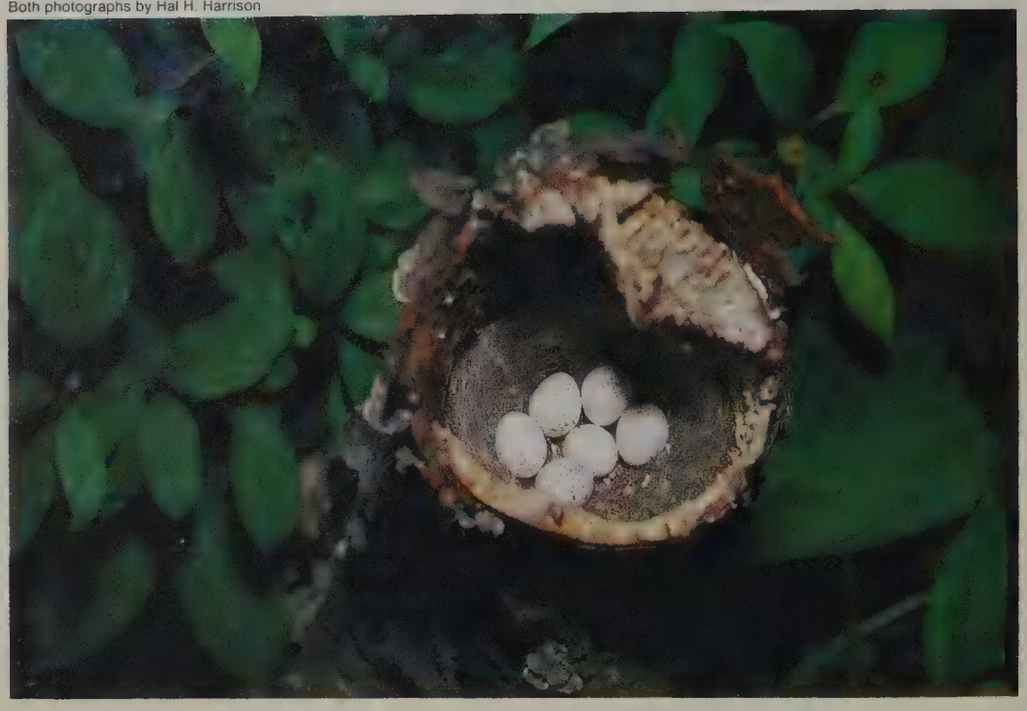
My western Massachusetts study area is a wooded residential district, well supplied with feeders. It includes some old deciduous forest and is bordered on one side by an old field. Since the chickadees breeding in the area are nonmigratory, the birds and their social organizations can be studied year-round.

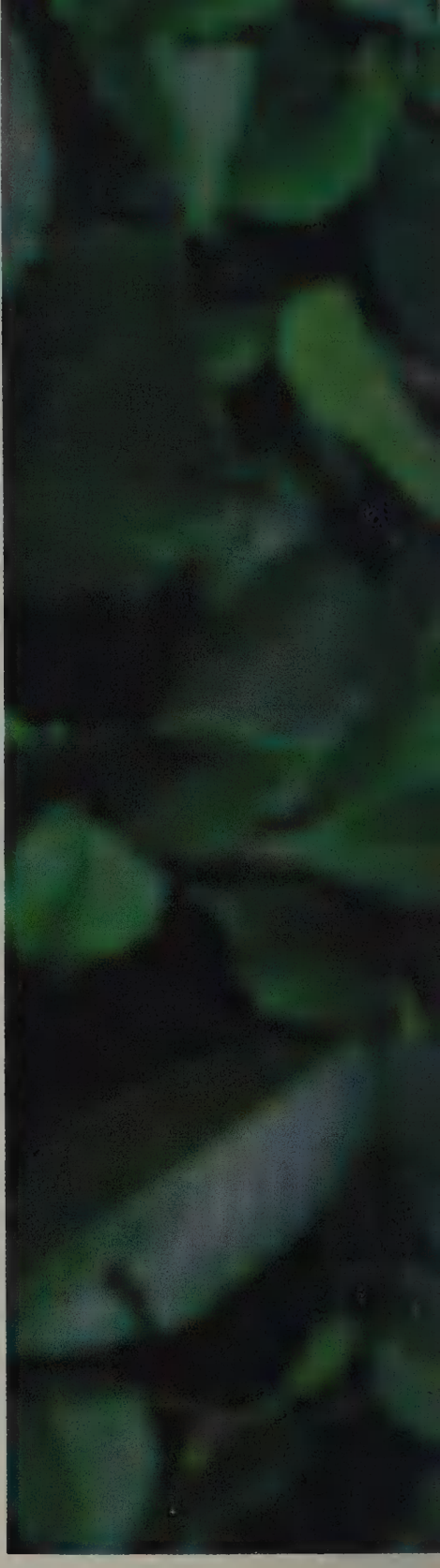
In winter each chickadee adopts one of two life styles: they are either regulars, always found in the same flock where I originally caught them, or floaters, which range among three or four flocks. What influence, I wondered, does the behavior of floaters have on the social patterns of black-capped chickadees?

In the spring and summer, chickadees live in monogamous breeding pairs. Each pair of successful breeders stakes out and defends a territory against all other black-capped chickadees. Territories, up to one-fourth of a square mile in my area, must contain an adequate supply of natural food, such as caterpillars, for both adults and nestlings. They must also have at least one suitable nest site, typically a rotten tree stump where chickadees can dig out a hole for their nest. The entrance is usually on the side of the stump, although it is not uncommon for it to be on the top. Both sexes share in the excavation duties; often several potential sites are dug out before the final selection is made. Only the female builds the nest, although her mate often accompanies her closely while she works. When the clutch is completed, the

A black-capped chickadee, right, pauses watchfully at its nest site, the stump of a dead birch. Both males and females typically excavate such cavities, where the females usually brood a clutch of five to nine eggs, below. Pairs that dominate the flock during the winter are most likely to secure breeding territories in the spring.

Both photographs by Hal H. Harrison





female incubates, while the male defends the territory and brings food for his mate on the nest. When the young hatch, both parents bring food for their nestlings. After leaving the nest, young chickadees generally remain dependent on their parents for up to four weeks before dispersing, often moving several miles away before settling down on their own.

At the end of the summer, a major social shift occurs. The older birds, undergoing postbreeding molt, no longer defend their breeding territories but gradually come together with several of the newly fledged young chickadees to form flocks. These flocks will occupy and defend a flock territory (usually two to three times the size of a breeding territory) against neighboring chickadee flocks. They persist through the winter until the birds break up into breeding pairs the following spring.

Floaters exist at all seasons within this alternating social system, but I've concentrated on floaters in the winter flocks because every young chickadee must enter the system as these flocks form in the fall.

Both regulars and floaters had a clear-cut linear pecking order in each of my study flocks. To determine these hierarchies, I considered chickadee A to be dominant over B if any of four things occurred: A supplants B (A arrives and takes over B's perch, forcing B off); A chases B; B tries unsuccessfully to supplant A; A and B arrive at a feeder simultaneously and A takes a seed first and leaves before B eats. I gathered most of my data on hierarchies at feeders, since in an earlier study I had found that chickadee peck orders away from feeders were the same as those at feeders.

This simple test, while only a brief episode in the life of a chickadee in nature, told me a lot about a bird's status. (In fact, the test isn't all that simple since I had to identify two birds from their bands, ascertain what happened during their interaction, and determine which bird went off with or without a seed—all in a few seconds through binoculars—before I could tell which bird was dominant.) After ranking the birds in an area, I had a better idea of their chances of surviving, of the likelihood of their breeding, and of the relative ranks of regulars and floaters.

Most chickadees in a flock are regulars, which spend the entire winter within a single flock. The twenty-three flocks I studied over five winters contained anywhere from six to fourteen regulars, with an average of nearly ten. The regulars apparently paired right from the start. Pairing, even by young birds, may actually be an integral part of autumn flock formation. I came to this conclusion because first, a twenty-three flocks had an even numb of regulars by the time the last regular ha joined; second, all flocks had even se ratios; third, the dominance rankin strongly suggested pairing; and fourth, o servations of spring breeding confirme the identities of specific pairs. Thus flock of ten regular members is probab made up of five pairs of chickadees.

There is another, grimmer fact abo these winter flocks. The area defended b a typical flock of five pairs is not larg enough for five breeding territories. Thu

even if all ten birds survive, only the few highest-ranked pairs will breed in the area at the end of the winter. Most of the others will be driven away. A few may find undefended areas to settle in, but most of the rest will not get to breed.

Several winter floaters associated with each of my flocks. They typically ranged among three or four flocks, with an established place in the peck order of each. They were all young birds that had never bred in the area before. Usually I found floaters either with a flock or moving singly, silently, and quickly from one flock to another. Floaters always ranked below all of the regulars of their sex in each flock hierarchy. Significantly, as floaters, they showed no sign of pair bonding.

Floaters also had dominance relationships, and their relative ranking always remained the same—if one bird ranked above another in one flock, it would remain higher in any other flock where both appeared.

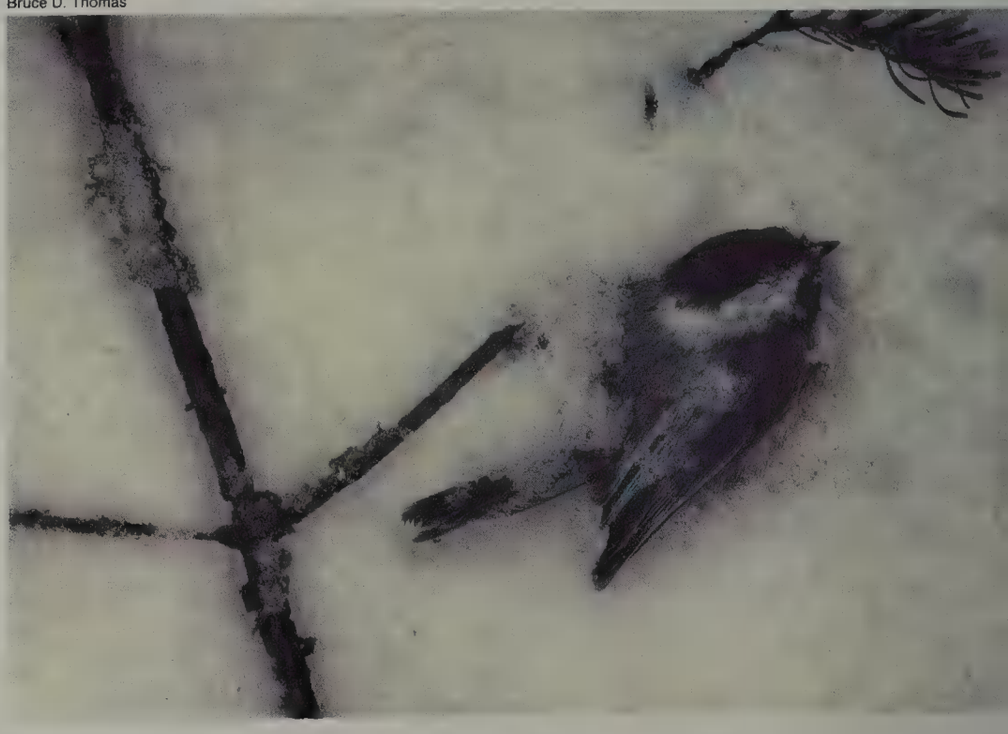
What possible interest can we have in these low-ranked birds that don't even have pair bonds? At first glance they do appear to be unsuccessful, irrelevant birds. But wait. What happens when the alpha male in a flock disappears—maybe picked off by the local cat or by a sharp-shinned hawk (my two highest sources of mortality)? Will the beta male take over? No. Instead, the highest-ranked male floater moves in as the dominant male of the whole flock. Similarly, if a high-ranked female vanishes, her place in the peck order is rapidly taken by the local dominant female floater, which settles down immediately and starts acting like the regular she has, in fact, become.

Over the past five winters, I have seventeen records of banded floaters—eleven females and six males—that succeeded in getting a regular's slot in this manner. All

John Sha

Below: In winter, chickadees may freeze to death or starve. Other common causes of mortality are predators, such as sharp-shinned hawks and house cats. Right: Just before spring, the flocks may start breaking into pairs, with males attending closely on their mates. Chickadees are for the most part monogamous; winter flock membership is made up of several mated pairs joined by a few unattached floaters.

Bruce D. Thomas



seventeen birds not only gained high-ranking positions with a regular mate in a flock but also obtained a breeding territory the following spring. Each bred with the mate of the bird it replaced.

Why don't such vacancies get filled by the next highest regular? How can the beta male sit by and allow a previously lowly floater to take over as the alpha male? When the floater inserts itself into the flock hierarchy and settles down, all intact pair bonds among the surviving regulars remain unchanged. Most regulars may actually be locked into their rank by their pair bonds, so that only the unpaired floaters are free to move in when a high-ranked opening occurs.

By far the most common sort of substitution (fifteen of my seventeen records) was a simple process involving just three birds: the regular that died, its mate, and the floater that took over the dead bird's slot. In two other cases, however, the process was a bit more complicated. If a flock contains at least two intact pairs of old, high-ranked birds, and if a member of the higher-ranked pair vanishes, its slot may be taken not by a floater (although one will try at first) but rather by a member of the second-ranked old pair. Then the floater will take over the vacant second-ranked slot.

Floaters do not fill a vacancy every time a regular disappears. First of all, no floater–floater pairs are formed: if the mate of a newly inserted floater dies, a second floater will not insert and pair with the first; instead, the first will take on its old rank again and resume floating. Secondly, floaters will only move in when a high-ranking bird dies. In the five winters of the study, thirty-eight regulars below the top three ranks of their sex lost their mates; all thirty-eight widowed birds remained mateless for the rest of the winter. These low-ranking positions apparently are less desirable because only the top two or three pairs in a flock will get a territory and breed in the spring (the ultimate goal of every chickadee).

If only the top few pairs in a flock get a breeding territory, why are there any lower-ranked regulars in the flocks at all? These low-ranked birds do have some chance of attaining a higher rank by spring. If both members of a top-ranked pair disappear in a winter, they will not be replaced by floaters because two floaters do not form pairs. Instead, the lower-ranked pairs all move up one notch in the hierarchy, so the fourth-ranked pair becomes third, greatly increasing its chances of breeding in the spring.

Soon after they become independent of their parents, young chickadees must enter the complex social system of their species. To be truly successful, a young chickadee should end the winter as a high-ranked regular, since normally only regulars can gain local breeding territories come spring. Potentially there are several options that can lead to this goal.

By far the easiest road to success is to enter as a high-ranked regular in the fall. Every summer a few local breeders die, leaving high-ranked slots that will clearly be the first to be filled in the fall. When all the top slots are taken, arriving young chickadees must choose among three other possibilities: entering as low-ranked regulars, high-ranked floaters, or low-ranked floaters. After the top slots are filled, the next to go are usually those of the high-ranked floaters. (Five of my successful floaters were banded and moving regularly from flock to flock well before all the regulars had joined the flocks. Later arrivals settle in as low-ranked regulars. The last to come join as low-ranked floaters, but some years no birds enter flocks at this level.

This sequence reflects the decreasing likelihood of gaining a breeding territory. The lucky young chickadees that get to enter as high-ranked regulars have it made—even if a mate dies, it will simply be replaced by a floater. For high-ranked floaters to succeed, a suitable opening must appear in one of their flocks, and the widowed bird that becomes the new mate must survive the winter. Success for low-ranked regulars depends on both members of at least one pair in their flock dying in the same winter. Low-ranked floaters can succeed only if something (mortality and/or successful insertion) removes all higher-ranked floaters and a suitable opening occurs.

Over the past winter, two sorts of chickadees probably visited suburban bird feeders: the regulars, which never stray from a few neighboring yards, and the floaters, which may range from feeder to feeder over many blocks. They each have a different strategy, but their goal is the same. The eventual winners may appear in your yard next summer, busily gathering caterpillars for their hungry offspring. □

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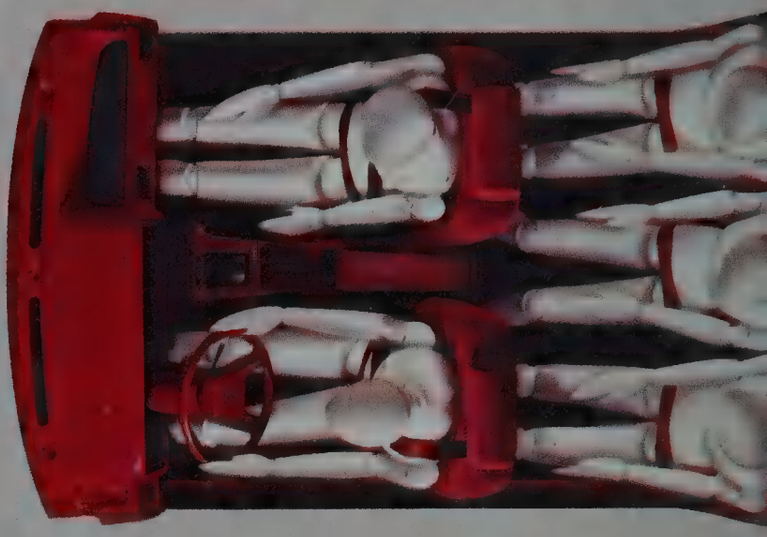

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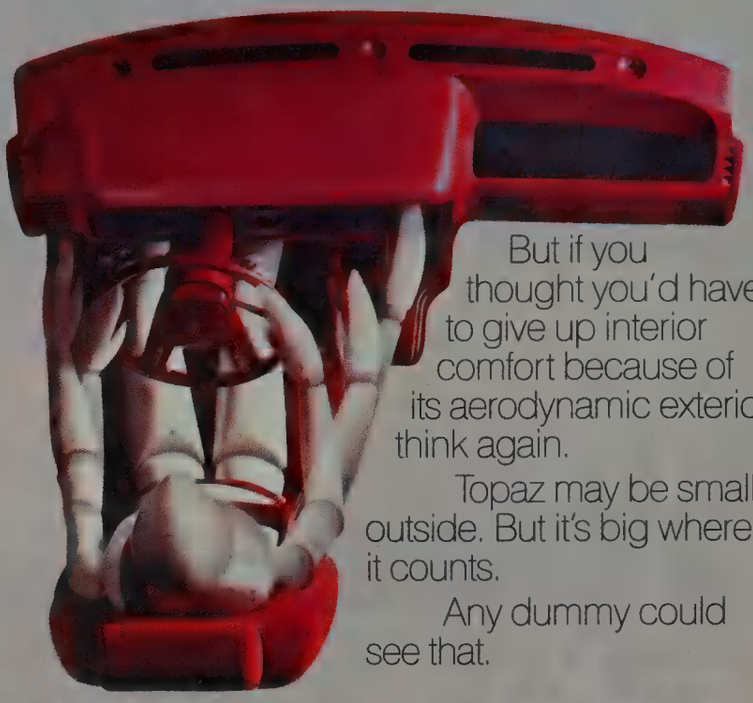

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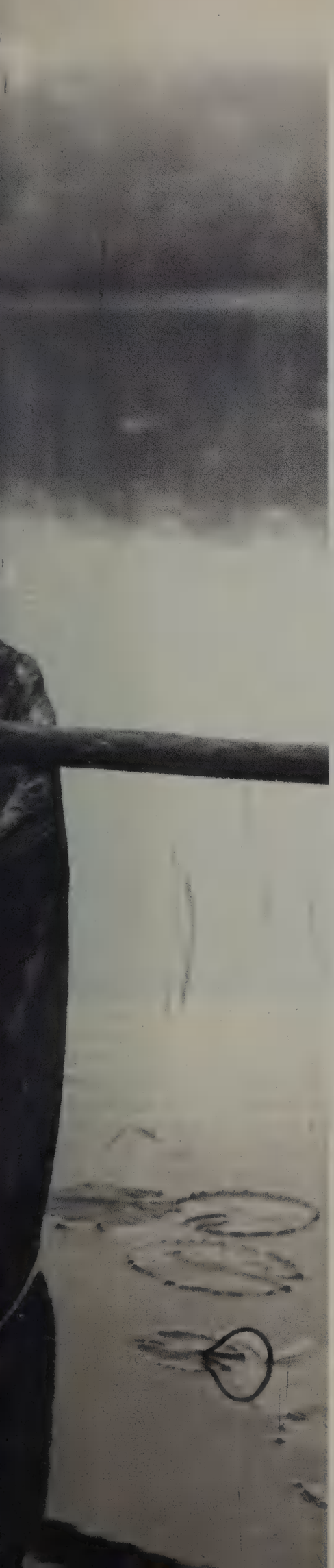


Bearing Witness

The Lacandon Maya's traditional culture survives in the images of Gertrude Blom

by James D. Nations

In 1939, Swiss-born political activist Gertrude Duby gained release from a fascist detention camp in prewar Europe and emigrated to Mexico to begin a new, nonpolitical life as a journalist. Instead, she became one of Mexico's most outspoken advocates for Indian rights and for the conservation of their tropical forest environment. Simultaneously, she emerged as one of Latin America's finest documentary photographers, producing images that illustrate four decades of change among Mexico's indigenous peoples.

In Chiapas, the southernmost state in Mexico, Duby met and married Danish archeologist Frans Blom. Together, they explored and mapped the Selva Lacandona, Mexico's largest tract of tropical rain forest and home to the Lacandon Maya Indians. Gertrude Blom's respect for the Lacandones earned her their trust and admiration, and she began to document both their traditions and their reaction to the cultural threats of the outside world. Decades later, when economic forces began to threaten the survival of the Selva Lacandona itself, Blom began an ongoing struggle to protect the region's people, plants, and wildlife.

Today, at eighty-three, Gertrude Blom is the living conscience of the Lacandon jungle, reminding us of treasures lost and of what we still stand to lose. Alex Harris, director of Duke University's Center for Documentary Photography, describes her as "part journalist, social activist, and explorer, part anthropologist, photographer, and ecologist, and, it would not be an exaggeration to state, part legend."

When Frans and Gertrude Blom first journeyed on muleback through the Lacandon jungle in 1943, they explored a region blanketed by more than 5,000 square miles of virgin tropical rain forest. At the time, the only other people in the area were 250 Lacandon Maya Indians, a handful of mahogany loggers, a few teams of chicle gum gatherers and crocodile hunters, and an incipient trickle of immigrant Tzeltal farmers from the nearby Maya highlands.

Down every jungle trail the couple rode they found wilderness, pristine rivers, and an abundance of rain forest wildlife. Peccaries and pacas dashed across the trails at the sound of the approaching explorers. Flocks of parrots and scarlet macaws flew overhead toward mountains that had not seen outsiders in centuries. A million insects hummed and whined and buzzed. By night, tapirs, jaguars, and kinkajous roamed the jungle near the expedition's

Excerpted from *Gertrude Blom: Bearing Witness*, edited by Alex Harris and Margaret Sartor. Photographs ©1984 by Gertrude Duby Blom. Text ©1984 by Center for Documentary Photography, Duke University. Published by the University of North Carolina Press and used with the permission of the publisher.

campsites. And as dawn appeared, the forest stretched on forever.

Today, more than forty years after the Bloms' first expedition to the Selva Lacandona, the jungle is an entirely different place. Almost half of the forest has been cleared and burned, and much of the rest has been degraded by loggers, colonists, and ranchers. Thin Brahman cattle search for forage where ceiba trees once arched over jungle waterfalls, and felled mahogany trees weigh down logging trucks that ply the region's growing network of asphalt and gravel roads. Bulldozers tear paths through primordial vegetation in an obsessive search for petroleum, and leftover hippies step down from second-class buses to search for magic mushrooms in the debris of the Maya past.

Once the secret refuge of Maya heritage, the Selva Lacandona has become the frontier home of more than 150,000 immigrant farmers and 70,000 Guatemalan refugees from a neighbor's bloody war. The only remnants of the rain forest's unviolated expanses persist in a few inaccessible valleys and in the haunting photographs of Gertrude Blom.

The ignorance, greed, and progress of civilization have begun their final round of destruction in the Selva Lacandona. The politicians' dream to incorporate the rain forest into the national economy will soon bear fruit on eroded hillsides and in weeded, wasted valleys.

Gertrude and Frans Blom's expedition to the Lacandon rain forest in 1943 was not the only significant event that affected the Lacandones during the 1940s. That decade also brought about the most dramatic change the twentieth-century Lacandones had ever seen—the massive invasion of their rain forest territory by colonizing farmers from other regions of Mexico. In a program similar to the United States Homestead Act, thousands of Indian and mestizo peasants were exhorted by government agents to move into the Chiapas lowlands in search of land and new lives. Ironically, many of these immigrant families were Tzeltal and Chol Maya, the descendants of groups who had been forcibly removed from the region by colonial Spaniards four centuries before.

Maya ruins

The *kaho,* "the community dwellers," as the Lacandones called the invaders, established colonies throughout the uninhabited rain forest between the Lacandon settlements. They began to clear and burn the forest to raise corn, beans, chilies, squash, coffee, and cattle. The Lacandones—who were reluctant to live near even nonrelated members of their own

group—were not pleased with these new arrivals. They drew their settlements into tighter patterns, concentrating on the rivers and lakes in the center of the jungle.

Unlike the Lacandones, the new immigrants raised pigs and cattle for sale in commercial markets. Such activities—and the sheer number of new people in the region—placed harsh burdens on the rain forest environment. Eventually, the immigrants' activities began to eradicate the forest itself. Instead of allowing agricultural plots to regenerate in natural forest, the Tzeltal and Chol Maya seeded their abandoned milpa plots in pasture grasses for cattle.

The final blows to the forest began during the 1960s, when the Mexican government began a program of road construction aimed at extracting the jungle's mahogany and tropical cedar trees. These logging roads pierced the core of Lacandon territory and triggered another massive influx of colonizing farm families. As this second wave of immigrants ate through the forest, wealthy Mexican cattlemen followed in their wake, buying up the families' cleared plots to create large ranches. Supported by generous bank loans, these colonists-cattlemen joined the state's politicians in envisioning the rain forest as one vast cattle ranch, and they set about turning that vision into reality. Where toucans and tapirs had lived only months before, the ranchers produced beef cattle for export to Villahermosa and Mexico City. More than any other act, the introduction of commercial cattle ranching into the Selva Lacandona spelled the death of traditional Lacandon society and of their rain forest environment.

The in-migration of farmers and cattlemen forced the Lacandones to abandon their isolated family settlements and brought them face to face with the modern world. During previous centuries the Lacandones had learned that by concealing their settlements they could avoid unnecessary contact with outsiders. But techniques acquired in earlier times—milpas and houses hidden behind a wall of jungle, trails that seemed to disappear—proved futile against the onslaught of change during the 1960s. As the region's population exploded, constant contact with outside groups became unavoidable. During the 1970s government relocation teams searched out the Lacandon families still living in isolation in the forest and moved them into the settlements of Mensäbäk and Najá in the northern jungle and Lacanjá Chan Sayab in the south.

Through nò choice of their own, the Lacandones had lost the isolation that, for centuries, had protected their lives and their traditions. Simultaneously, the Lacandones began to lose the rain forest ecosystem that had supported both the old ways and their lives.

Today's adult Lacandones are the transition generation in this dramatic wave of change. Their predecessors lived in a world uninterrupted by radios, airplanes, and chain saws. Where their fathers hunted jaguars with bows and arrows, their children now drive rattling trucks down muddy jungle roads. A Lacandon man in the 1980s may begin his day with a chant as old as the Maya themselves and end it hunched over a battery-powered record player blaring raucous mariachi music in a language he does not understand. In a very real sense, the Lacandones of today have inherited both the legacy of the ancient Maya and the dubious gifts of the twentieth century.

Gertrude Blom has captured this generation of Lacandones in a sequence of photographs that allows us to see how changes have affected them through the decades. In watching these people adapt, we see the effects of our civilization on traditional peoples throughout the world. In turn, their transformation teaches us lessons about ourselves, for we too are a transition generation.

When Blom began to photograph the Lacandon Maya, men still hunted forest animals as they had for centuries. They continue to hunt today, but they use rifles rather than the bows and arrows of their fathers. Lacandon women still grind corn as they have for centuries, but—except for religious ceremonies—they use aluminum grinders manufactured in distant cities. In recent years, some men have cut their hair in Western style and traded their tunics for polyester shirts and pants, but most still dress in the traditional white cotton *shikur,* even though the cloth comes from the city. In some Lacandon settlements, families have exchanged the gods of rain, fire, and forest for the flashlight slide shows of evangelical missionaries. Other families remain hidden within the forest, burning copal incense and small rubber figures to the silent Maya gods.

Modern Lacandones remain divided into two distinct groups, northerners and southerners, so called because of their general location in the Selva Lacandona. Most southerners live today at Lacanjá Chan Sayab, although a few hang on at the older community of San Quintín. Northern Lacandones live on the shore of Lake Najá and near Lake Mensäbäk and in a few isolated family settlements scattered across the northern Selva Lacan-

Deforested hillside

dona. Counting all the families of both groups, the Lacandones number slightly over four hundred people.

Lacandon men let their long, black hair fall over the shoulders of their white tunics. Northerners distinguish themselves from southern men by cutting bangs across their foreheads. Southern women leave their hair long and flowing and wear colorful versions of the men's white robes. Northern women pull their hair back in a single braid decorated with the yellow breast feathers of the toucan, an exotic rain forest bird. They wear a shorter version of the men's white tunic over a colorful skirt decorated with ribbons. For both men and women, the longer sleeves and hem of the southerners' tunics give outsiders a clue to their origin and provide the source of one of the northern Lacandones' names for their southern relatives—*chukuch nok,* "the long clothes."

Although many northern and southern Lacandon traditions are similar, it is religion that most differentiates the two groups. Religious beliefs in north and south had always varied, but southerners abandoned the traditional Maya gods during the first half of the century, when their leader died in a devastating yellow fever epidemic and his successors failed to effect a smooth transition in the chaos that followed. In 1957, after thirteen futile years of missionary work aimed at converting the northern Lacandones of Najá, an American Bible translator set up camp among the southerners. His efforts among the disoriented southerners were rewarded by the mass conversion of almost all the families at Lacanjá.

Recent missionary efforts have made inroads among the northern Lacandones as well. During the mid-1970s, a visit by a Yucatec-speaking Maya from northern Yucatán came shortly after the death of the Mensäbäk leader's only son. The missionary exhorted the men to reject their old religion. "Give up your gods and devil worship and your children will not perish," he promised. In the same breath, he promised a gasoline-powered electric generator, a road, and visits by a doctor. The settlement's leader accepted the promises. Most of the settlement followed, although a few families slipped into the jungle to resume their chants and prayers. Today in Mensäbäk, a Seventh-Day Adventist church stands on the tallest hill in the community, and the children sing "Jesus Loves Me" in Lacandon. They scoff at the children of families who have not converted and call their parents "animals in the forest."

Men with hunting rifle

Lacandon man in a jungle thicket

Lacandon men in traditional dress

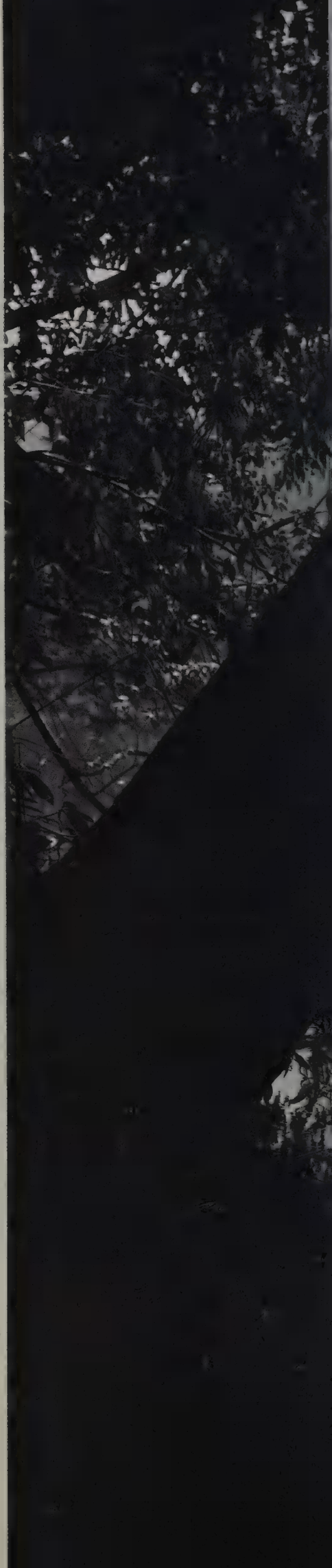
Only a few isolated families and the ıorthern Lacandones of Najá maintain he traditional Maya religion. Led by Chan K'in Viejo, the octogenarian *t'o'ohil* the great one) of Najá, they have resisted ɔoth missionary efforts and the tempta- ions of the technological world. When ɔmeone falls ill or when it is time to pay he gods with *balche'*, a mildly intoxicat- ng drink made of tree bark and the fer- nented juice of sugar cane, they lift clay god pots down from the sacred shelf of the god house and place them gently on ma- ıogany boards covered with fresh-cut ɔalm fronds. Chan K'in begins to chant in ı resonant voice: accusing, promising, of- fering to pay the gods with incense and small human figures molded of rubber from trees in his garden plot. He leans ɔver the tiny rubber figures and whispers, "Wake up, wake up." Then he places hem on flaming copal incense in the god ɔots, to be consumed and carried to the af- erlife to pat out the gods' tortillas and serve them food and corn gruel.

Thirty years after Gertrude Blom's first rip to the Selva Lacandona, I stood on the nud-and-grass airstrip in the Lacandon settlement of Mensäbäk and watched a Cessna bush plane bounce to a halt before ı group of thirty Lacandon Maya men and women. The Lacandones waited motion- ess while three Mexican businessmen emerged from the plane like space travel- ers from a time warp. Standing at the edge of the rain forest, with bare feet and white cotton tunics, the Lacandones looked more like figures from a lost Maya codex han like a reception committee on a jun- gle airstrip.

After the businessmen had perfunc- orily greeted the Lacandones, a buxom young woman in high heels and polyester dress stepped down from the plane and be- gan snapping photos with an Instamatic camera. The businessmen pulled bolts of cheap cotton cloth from the plane and tore them into sections to hand out to the Lacandon women. Then, amid all the hub- bub, they lifted thick documents from a briefcase. None of the Lacandones could read and only a few spoke Spanish, so no time was wasted on fine print or negotia- tions. After the Mexicans' hurried ex- planation, the Lacandon men lined up and eagerly affixed their thumbprints to the contracts. The conference completed, the group piled back into the plane and took off for the settlements of Najá and La- canjá, where they would repeat the scene and close two more deals.

Twelve months later, with legal con- tracts filed, the government-owned log-

Lacandones in dugout canoes



ging company that the businessmen represented bulldozed roads toward the Lacandon communities and began to rattle the hills with chain saws and falling trees. During the months that followed, they extracted thousands of mahogany, tropical cedar, and ceiba trees from the Lacandon lands. According to the foreman of one logging team, in a single period of twenty days his group wrenched two million dollars worth of logs from the rain forest. The Lacandones grasped the full meaning of the contracts they had signed when workmen began to log the hillsides at the edge of their settlements.

Not all the Lacandones had been so quickly duped into selling their rain forest heritage. Asked by government officials to sign the logging contracts, Chan K'in Viejo advised them that the jungle's mahogany trees were not his to sell. "I didn't plant the trees," he said. "They're God's," meaning Hachäkyum, the major Lacandon deity. "Go ask him."

But of course they didn't. Instead, through a suspect political manipulation, government agents made the old man's son the *presidente* of the Najá settlement and obtained his signature in exchange for a truck and a headful of promises.

Watching this greed-fueled destruction of the Lacandon rain forest was my introduction to the problem of tropical deforestation. I later learned that the devastation of the Selva Lacandona is only a small part of a much larger process of destruction—a process that threatens to eliminate much of the world's tropical rain forest, its peoples, animals, and plants, before the turn of the century.

Throughout the world, almost 40,000 square miles of tropical rain forest are cleared and burned each year in the name of survival, progress, and profits, and another 40,000 square miles are degraded by logging, fires, and livestock grazing. The repercussions, says biologist Edward O. Wilson, will be worse than "energy depletion, economic collapse, limited nuclear war, or conquest by a totalitarian government. It is the folly which our descendants are least likely to forgive."

Ironically, we know very little about what we are destroying. Only one out of six tropical organisms has been described and named by scientists. The world's remaining rain forests contain twice as many unknown species as scientists have examined and classified since Linnaeus began the process 230 years ago.

Some of the reasons for conserving the world's tropical rain forests are economic—new medicines, food crops, industrial fibers, gums, spices, dyes, resins, oils, lumber, cellulose, and wood biomass. On the other hand, some of the reasons are ethical or aesthetic. Ecologically conscious individuals usually require only one argument about why we should preserve large sections of the world's tropical rain forests: Rain forests have enriched the earth for more than one hundred million years, they are the cradle of terrestrial evolution, and they are "the richest and most exuberant expression of life on land," as ecologist Lawrence Hamilton has noted. As the home of almost half of the earth's plant and animal species, rain forests form a crucial element in our global ecosystem.

Finally, some of the reasons for conserving rain forests are humanitarian. Gertrude Blom's writings, speeches, and photographs bear witness to one culture being lost to the destruction that is overwhelming our planet's tropical forests. □

Future Farmers of the Sea

Tiny marine animals called foraminifera are waiting in eddies for a new geologic age to arise

by Pamela Hallock

Countless billions of tiny, delicately shelled creatures known as foraminifera have inhabited the seas of our planet beginning more than 500 million years ago and persisting to today. Hundreds of lineages of forams have evolved, diversified, and gone extinct through the geologic ages.

Forams are found everywhere in the oceans, from deep beneath the Arctic icecap to shallow tidal pools in the tropics. Often smaller than grains of salt, forams can be found attached to rocks and seaweed, where they capture food by straining bacteria or microscopic plankton from the water through sticky strands of protoplasm known as pseudopods. Many forams move freely, though slowly, along the sea bottom, using their pseudopods to pull themselves along. Others live as plankton, drifting freely in the waters of the open ocean.

In the late eighteenth and early nineteenth centuries, scientists thought that forams were minute relatives of the chambered nautilus. Not until the mid-1800s did they realize that the living foram is very much simpler than a nautilus—that it is actually a single-celled, amoebalike protozoan.

Alcide d'Orbigny, one of the first paleontologists to study microscopic fossils, recognized that the remains of these tiny creatures were plentiful in many types of rocks and predicted that they could be used to correlate ages of rocks in widely separated regions. In the early 1900s, Joseph Cushman pioneered the use of fossil forams to tell the relative ages of rocks encountered in the course of drilling oil wells. Because of their importance for economic geology, foraminifera have been carefully described and cataloged. The American Museum of Natural History has one of the most extensive collections of these tiny fossils, and its voluminous technical publications about them are purchased by oil companies and geology libraries throughout the world. But most studies have stopped once the animal's fossils have been described, named, and dated. Until recently, almost nothing was known about the natural history, the ecology of most forams.

Foraminifera may be smaller than grains of salt or as large as poker chips. Less than one-tenth of an inch in diameter, this foram was photographed at 600 times magnification through a scanning electron microscope.

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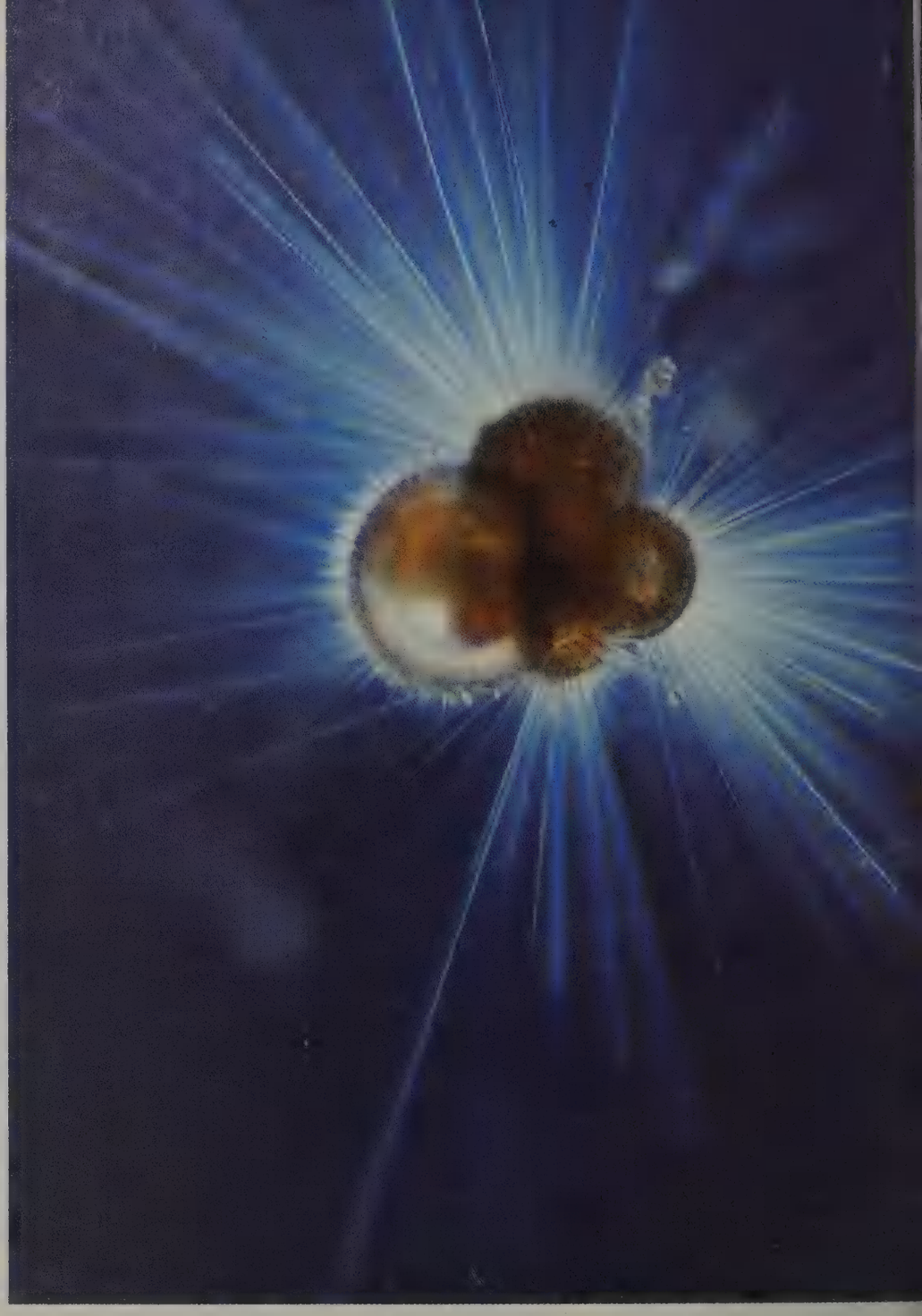


In the past two decades, however, scientists from several disciplines have begun to study the life histories of forams, particularly the larger species that survive today. As so often happens, these seemingly simple, single-celled creatures turn out to lead marvelously complex lives, and their histories cast light on some of the most profound questions of evolution.

One special group, known as the larger foraminifera, has received some of this newly focused attention. Larger forams are structurally more complex than the smaller varieties and range in size from that of a rice grain to that of a poker chip. (For a foram, being poker chip size is comparable to a marine mammal being blue whale size.)

Larger forams today are found mostly in warm, clear, shallow waters in the tropics and subtropics, often living on seaweeds or seagrass. Most fossil larger forams are found in limestones of shallow-water origin. In fact, the nummulitic limestones, from which the pyramids of Egypt were constructed, consist primarily of larger foraminifera shells.

In 1970, when I was a graduate student in oceanography at the University of Hawaii, geochemist Keith Chave suggested I use my background in biology to study rates of sediment production by forams. (The problem is of geologic interest in Hawaii and on other islands of the Pacific because foram shells make up so much of the sand in the coral reefs and beaches there.) At about the same time, several other scientists—in the United States, Europe, and the Middle East—were, independently of one another, beginning to study various aspects of the larger living forams. One result of all these studies is the discovery—which fossils would not reveal—that almost all large forams are hosts to algae. The outer, translucent chambers of the shells are, in a sense, small greenhouses for crops of these single-celled plants.

Nitrogen and phosphorus, essential nutrients required for growth by all plants, are present in the forams' waste products. These wastes provide the symbiotic algae with a continual source of nutrients. In turn, algae photosynthesize—that is, use the sun's energy, carbon dioxide, water, and foram wastes to make sugars and other organic matter. Keeping some of what they produce for themselves and giving up the rest, the algae provide their hosts with an internal food source. In addition, because algae take up carbon dioxide and give off oxygen, they serve as kidneys and lungs for the forams. These functions may have been crucial as forams became larger, since they lacked respiratory and excretory organs of their own.

The algae–foram relationship is the key to answering many questions about larger foraminifera. The easiest is, why do larger forams normally occur in relatively shallow water or in limestones of shallow-water origin? The answer is that their algae need sunlight, and sufficient light for photosynthesis penetrates to a maximum depth of about 500 feet (and then only in extremely clear water). Other difficult puzzles about these foraminifera—concerning their feeding methods, size, complexity, and episodes of evolution and extinction—require more consideration.

For most animals that capture prey, the captured organisms supply all the energy needed to live and grow. But larger forams capture bacteria and plankton primarily to supply nitrogen and phosphorus to the algae living within them. Under what circumstances is that symbiotic way of life advantageous? One answer: when the supply of dissolved nitrogen and phosphorus is very low.

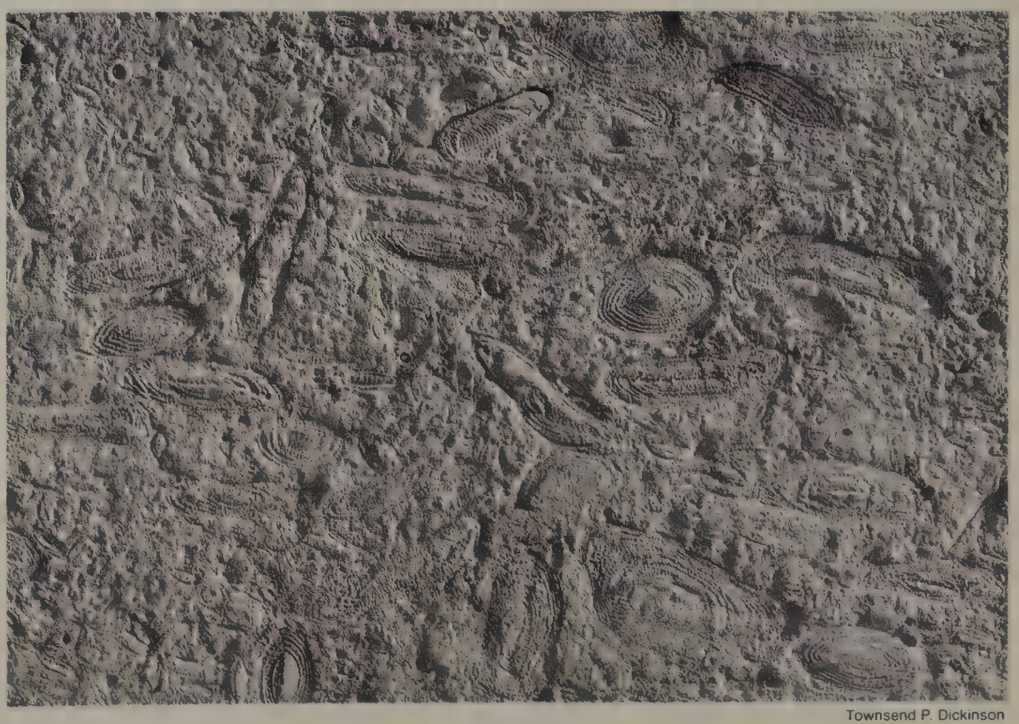
In the marine realm, the richest environments are near river mouths or in areas where upwelling currents bring dissolved nitrogen and phosphorus to the sea surface. Most surface waters of tropical and subtropical oceans, however, are far from

Forams use strands of protoplasm to capture food and to move about. Left: Shells of some species may be covered with delicate spines. Below: The whorled shells of larger forams are common components of sand on Kahuku beach, Hawaii. Bottom: Forams flourished during geologic eras when sea levels were high, and their fossils dominate many limestone strata. Foram fossils are easily seen in the base of the New York City monument known as Cleopatra's Needle.

Rudolf Röttger

these major sources of dissolved nutrients. Interestingly, many of the organisms that flourish in nutrient-poor areas—from forams of the open ocean to corals of the Caribbean shallows—are hosts to algae. The question is, just how does this symbiotic relationship improve an animal's ability to nourish itself?

When an animal with algal symbionts captures another organism for food, the animal in the association digests that food, using perhaps 10 percent or less for growth. The other 90 percent or more is burned in respiration to provide energy needed to live and capture more food. The nutrients originally incorporated in that 90 percent are broken down into waste products. The algae can use those "waste" nutrients and sunlight to produce by photosynthesis nearly as much organic material as the host used in metabolism. Even if

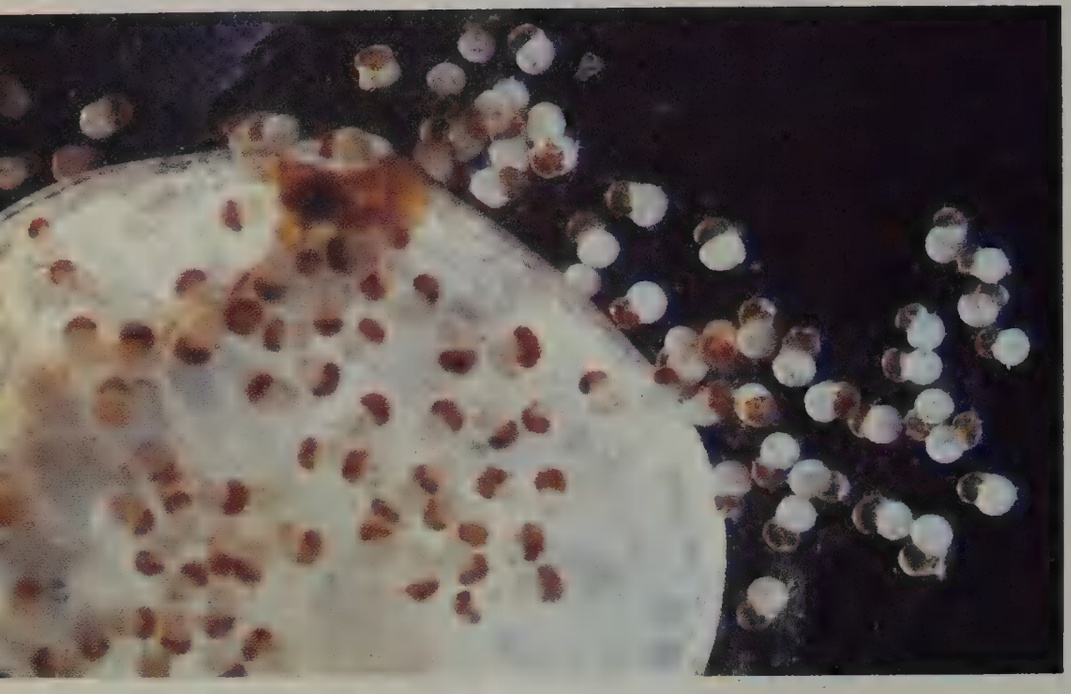


Townsend P. Dickinson

Rudolf Röttger

A larger foram may reproduce itself asexually by undergoing multiple cell divisions. Below: Hundreds of embryos have developed from the protoplasm of a single parent, and each shares some of the algae that lived symbiotically within the adult. Right: This foram has just added a row of new chamberlets on its outermost margin. The thin shell allows light to penetrate so that the algae living within may photosynthesize. The inmost chambers are darker because they have been more thoroughly colonized by algal cells.

Rudolf Röttger



the algae give some or most of that organic matter back to the host or if the host digests some of its algae, the host will again burn about 90 percent of what it gets; the nutrients in that 90 percent will go back to the algae for reuse. The nutrients can be recycled again and again, providing an indefinite amount of energy. The host–symbiont system ultimately grows by nearly the same amount of organic matter as originally contained in the food captured. That is, while an animal without algal symbionts might grow 10 grams for every 100 grams of food eaten, the animal with algal symbionts can grow nearly 100 grams for every 100 grams eaten. That is about a 10 to 1 growth advantage for the symbiont-bearer.

The scarcer the food, the greater the advantage of symbiosis. If, say, 99 percent of the animal's food must be used to live and find more food, the animal in the host–symbiont system will have nearly a 100 to 1 advantage over the animal without symbionts. Most algae cannot survive on their own when nutrients fall below a certain level. As nutrients and food become even scarcer, symbiosis becomes highly advantageous for both host and algae.

With algal symbiosis, certain organisms—larger forams, corals, and some plankton—flourish in the warm open ocean, the central Pacific, and reef environments worldwide where food is scarce and sunlight is abundant.

And why are larger foram shells so complex? Most forams build chambered shells, adding new chambers as they grow. A shell is rather like a house; the chambers are equivalent to rooms. Ceilings and floors separate the rooms from the outside, as do the outermost walls. Interior walls separate chambers. Some shells are multistoried, with interior ceilings and floors that also separate chambers. In larger foraminifera, complex interior structures include chambers divided into chamberlets; corrugated or pitted walls; and internal canal systems that run throughout the shell. These wall modifications increase the shell's inner surface area. Most of the algae are found close to the walls and ceilings, while most of the foram's own protoplasm is concentrated in the center of the chamber or chamberlet. The ceilings and floors must be thin for light to penetrate into a large shell, but additional wall structures provide added strength, especially in shells that may be an inch or two in diameter and perhaps a tenth of an inch in thickness. The internal canal systems serve as a sort of circulatory system, presumably an important asset in very large foraminifera.

Another interesting question is, of what advantage is large size? Modern larger foraminifera must live as much as a year to grow to a size of a few tenths of an inch in diameter. Very large foraminifera of ancient times must have lived for several years, perhaps as many as ten. Such longevity is particularly perplexing in simple creatures such as forams, whose primary mode of reproduction is an asexual process in which the parent simply divides its protoplasm among its offspring, ending its own life as an individual. In such cases, long life means fewer chances to reproduce. So under what environmental conditions might longer life be a greater advantage than the ability to produce offspring in a short period of time?

When a foram divides asexually, the parent cell passes along its symbiotic algae to its offspring. (Forams also repro-

duce sexually, but sexual reproduction is riskier. Each newborn must find its own algae, one of the reasons that very few sexually produced offspring survive.)

Field studies indicate that larger forams lead relatively safe lives from the time they reach a size of about a tenth of an inch in diameter until they reproduce. Most juveniles, on the other hand, perish—in two species that produce a large number of fairly small young, more than 99 percent died. One of these species lives in very shallow, wave-swept reef flats; the other is found in slightly deeper, quieter environments. Although otherwise similar, the shallow-water species lives about three times longer, grows about three times larger, and most importantly, produces about three times as many young per parent. These observations indicate, as do computer simulation models, that increased parent size can be a successful adaptation to high juvenile mortality in foraminifera.

Far and away the most intriguing question concerning forams is why lineages of larger species evolved and then died out several times in the history of the earth. The oldest group of larger forams, the fusulinaceans, evolved more than 300 million years ago in shallow lime- and shell-dominated seas at about the same time that the early amphibians and the first primitive reptiles were invading the early swamps. The fusulinaceans died out about 225 million years ago when the seas receded as the then-existing continents collided to form the ancient supercontinent of Pangaea.

About 75 million years later, Pangaea was breaking up, dinosaurs roamed the earth, and the seas again invaded low-lying parts of the continents. During the subsequent tens of millions of years, in the resultant shallow seas, several different lineages of smaller forams gave rise to larger descendants. Then, about 66 million years ago, roughly when the dinosaurs perished, most of the larger species died out abruptly for the second time. During the next 60 million years, communities of large, complex forams evolved twice—at about 55 and 30 million years ago—and died out twice—at about 35 million and 15 million years ago.

The fossil record indicates that high sea level and a warm climate were the necessary conditions for the evolution of larger forams. When sea level is high, the earth's surface becomes more evenly heated because water holds heat better than land. At those times, the marine temperature gradient between the tropics and the poles

is reduced, with sea water in polar regions as much as 25 degrees Fahrenheit warmer than during low stands of sea level.

During higher stands of sea level, vast, low-lying continental areas were covered by shallow water. Warm, nutrient-deficient seas developed gradually over millions of years, providing time and selective advantage for the evolution of long-lived, heavily armored, highly specialized algal-symbiont-bearing organisms—including reef-building corals and the larger forams.

A simple drop in sea level could have caused the elimination of the most specialized larger forams. Most of their shallow-sea habitat became dry land, and much of the remaining sea would have been made unsuitable by the sediments and nutrients in river runoff from the increasing land area. As the seas receded and high latitudes cooled, deep ocean circulation would have brought nutrients, long trapped in sluggish deep waters, up to the surface. Fast-growing algae and animals that fed on those algae would have bloomed, preventing light from reaching the underwater environment and thereby degrading the habitat for algal-symbiont-bearing marine species.

The two most recent episodes of the evolution of larger forams, one about 55 to 35 million years ago, the other about 30 to 15 million years ago, coincide with the development of high sea levels and warm climates. Each episode ended as high latitudes cooled and deep ocean circulation accelerated, apparently as a result of changes associated with the movement of continental plates.

When the larger forams proliferated, sea levels were 1,000 feet or more above present levels. Now, because deep ocean circulation is active in modern oceans, food resources, even in areas considered nutrient-deficient—such as the subtropical oceans—are probably quite rich compared with those of former times. Modern larger forams are fairly small and their shells are relatively simple compared with some of their earlier relatives.

When—at some time in the future—sea levels rise and warmer climates return to the higher latitudes, very large and complex forams may well flourish for the fifth time. □

Larger foraminifera are common in the warm, shallow waters of this Hawaiian rock pool. The characteristic golden color of some of the forams comes from diatoms (microscopic algae) living within their shells. The small, candy-striped foram in the foreground is host to a species of red algae.

Rudolf Röttger

Art Beneath the Sea

by Victor B. Scheffer

WITHIN A RAINBOWED SEA, by Christopher Newbert. *Beyond Words Publishing Co., $49.95; 208 pp., illus.*

Here are 158 exquisite photographs, printed one to a page in full color, of animals that cling to coral reefs or crawl among them or drift or swim in adjacent waters. A few pelagic species—whales, dolphins, sharks, a green turtle, and a fur seal—are also portrayed. All were photographed underwater in their native haunts in the Red Sea, the Galápagos, Cozumel, the Cayman Islands, Roatan, Belize, Hawaii, Fiji, Truk, Ponape, Palau, the Great Barrier Reef, and the Coral Sea.

Tropical reef communities display an unparalleled variety of forms, textures, and colors, partly because they are among the oldest on Earth and partly because they have evolved in regions uncommonly hospitable to life—they are the survivors of an experiment that has continued nonstop for at least a billion years in warm, sunlit laboratories. Little wonder that these communities are now populated by hundreds of thousands of species occupy-

Flamingo tongue shell on sea fan

All photographs by Christopher Newbert

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Clownfish in sea anemone

ing countless ecological niches. The author puts it this way:

The reef is a marvelous compression of life, a proving ground for genetic design. The intense competition for food and space by members of this community is fuel for the engine of evolution. On the reef we have a special opportunity for intimate contact with the inner workings of this endless, intriguing process.

The book is designed to be "a visual poem, photographs and words celebrating not just the intricate fabric of life which evolution has woven into the sea, but the origin and life force common to all things." I suggest, however, that the product is more a guide to artistic inspiration in nature than a species chart of Darwinian adaptation. Its photographs are clean and sharp; they have an arresting, posterlike quality. Newbert often zooms in to frame a single crab larva, the eye of a fish, the tentacles of a sea anemone, or the siphon pore of a tridacna clam. (He's fond of tridacna clams; he gives us eight views of their parts.) As a result of his absorption with what may be called architectural detail, his work stands apart from that of many or most undersea photographers who aim to show us the whole animal.

Some reef organisms display their charms openly. They are "found art" and present no photographic challenge. Others hide their beauty until someone like Newbert comes along and reveals it through expert attention to lighting, scale, angle of view, and background.

Several of the photographs in the book will startle zoologists. Five pilot whales pass in review beneath the surface, their slick bodies aligned in military precision. A dense-beaked whale and a melon-headed whale approach the camera—the first of their kind, I believe, to have been photographed underwater in the wild. A flying fish soars on silver wings outspread against a black sky . . . in fact, it is swimming deep in the Pacific off Hawaii's Kona coast at night.

The book's brief text is scattered among the photographs. For the most part it explains how Newbert feels when he moves quietly through a sun-dappled sea or dives at night when the reef creatures that habitually hide during the day may expose their unexpected charms. On such occasions, the brief flash of a strobe lamp is the first full spectrum of light that the creature has seen or will ever see. Newbert recalls one of the many times when he simply flowed with the current, studying the life around him.

Winding, twisting, stretching out, then reforming, they moved in perfect synchronization. Thousands of tiny fish, none ever missing a beat. Sunlight streaming through the water flashed silver as they turned in unison, a single being, a single spirit. I was mesmerized by their rhythm. How did they know when to turn? And where? By what mysterious signal did their rhythm change? A beat goes on underwater and there have been those moments when the beat and I merged.

Yet I wonder a little about this book, as I have wondered about others in which graphic art and prose were combined. Would not either expression by itself have been more convincing, more eloquent? Quite apart from the accompanying words, Newbert's images of undersea life seem to me as complete as one could wish. Witness the goatfish eye in burning reds and black, which can be seen as a vision by Robert Blake. Crinoid arms are bursting fireworks. A clownfish peering from the pulpy fingers of an anemone is a cartoon without words. Maxfield Parrish, in his most exalted moments, could never have painted the blues and oranges of Newbert's soft coral tree. Poised in watery space, a Spanish dancer nudibranch and a pair of fire gobies hold for applause. Other

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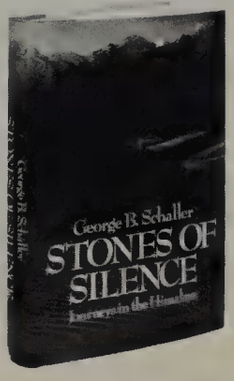

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Arrow crab

scenes are jungles on undiscovered planets, sensual forbidden fruits, gatherings of amoeboids, the frosts of new chemicals, or strange and wondrous things in an inventor's shop. All these images are landscapes of the mind. They deserve careful study by designers, sculptors, choreographers, and others who find inspiration for their art in the outdoor world.

Newbert, formerly a *National Geographic* staff photographer, lives on the island of Hawaii and is the author of two best sellers, *The Australians* and *The Hawaiians*. The design of his latest book is a tribute to the author's "fierce commitment to quality." Each photograph is printed in glossy inks on white stock. The surrounding page is beige, with a matte surface. Thus any white parts of the original photograph are saved, while the viewer is spared the distraction of a white frame.

And there's a promotion appeal. Each copy of the book (which can only be purchased at Walden Bookstores across the country) contains a coupon promising that a tree will be planted, in the name of the buyer, on Hawaii's Molokai Island.

This is a fine book. One can only wish Chris Newbert happy hunting when again he ventures into Shelley's realm of "The sea blooms and the oozy woods which wear / The sapless foliage of the ocean."

Victor B. Scheffer is a naturalist and author retired from federal wildlife service. His most recent book is Spires of Form: Glimpses of Evolution.

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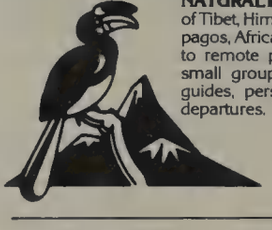

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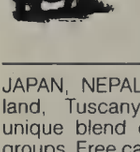

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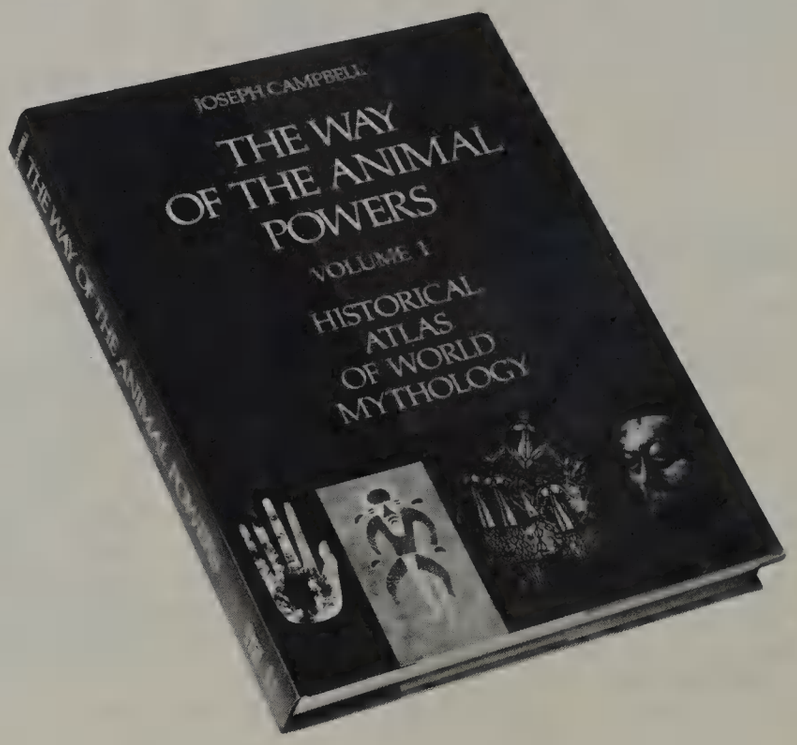

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Tough Nuts

Despite some superficial similarities, Brazil nuts and macadamia nuts present a study in contrasts

by Raymond Sokolov

The macadamia and the Brazil nut are not related in any way except one. They are very hard to crack. I was once given a bag of unshelled spherical macadamias that defied nutcrackers and hammers and only surrendered their edible kernels when I pounded them between two large rocks.

In Hawaii, where the largest commercial macadamia plantings grow, nut stores recommend screw-type nutcrackers fitted with small cups to keep the macadamias from escaping as pressure is applied. Some people drive cars over them. But most consumers buy mechanically prehulled macadamias at a fabulous price—$10 a pound approximately—caused by high Hawaiian costs and the multiple harvesting necessitated by the macadamia's impractical habit of not bringing all of its fruit to maturity at the same time.

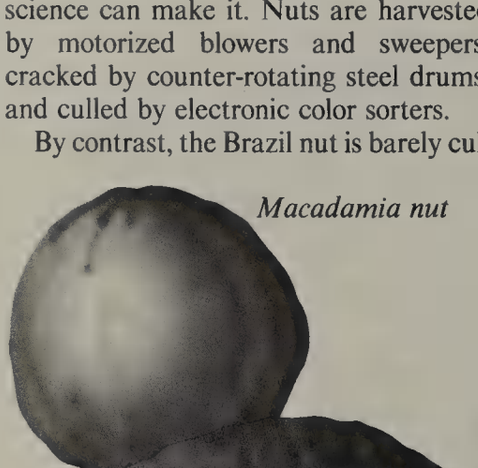
Macadamia integrifolia is, nevertheless, a "modern" plant, intensely cultivated, hybridized, and grafted. This is all very recent. In fact, the first cultivar is still producing nuts in Queensland, Australia, where a Brisbane botanist named Walter Hill planted it, from seed cracked in a vise, in 1858.

Hill had discovered this evergreen of the Proteaceae family the year before on an expedition with that patriarch of Australian botany Ferdinand von Mueller. As Frederic Rosengarten recounts the story in *The Book of Edible Nuts* (Walker and Co.), Mueller named the "new" tree after his friend John Macadam, a Scottish physician who was secretary of the Philosophical Institute of Victoria. By legend, Macadam never tasted a macadamia. Before he was able to sample the nut that would make him immortal, Macadam died aboard ship on the Tasman Sea, heading for New Zealand. He had cracked his ribs in rough weather, contracted pleurisy, and never recovered.

We also know the name of the man who first brought the macadamia to the big island of Hawaii, where it flourishes today as nowhere else and, as we munch, is replacing the traditional Hawaiian crops of sugar and pineapple on thousands of acres of land. The Johnny Appleseed of the macadamia was William Herbert Purvis, a prophetic soul who gathered seeds near Mount Bauple in Queensland, Australia, and put in seedlings at Kukuihaele, Hawaii, about 1882. One of the trees he planted is alive and still fecund as it enters its second century.

Today's macadamia industry is as mechanized and up-to-date as money and science can make it. Nuts are harvested by motorized blowers and sweepers, cracked by counter-rotating steel drums, and culled by electronic color sorters.

By contrast, the Brazil nut is barely cultivated at all, even after several centuries of international export trade in this economically valuable wild fruit. A modern excavation in Alexandria, Virginia, unearthed Brazil nut shells dropped there 200 years ago.



Macadamia nut

Brazil nut

Today, Brazil is still, in the words of Charley's Aunt, "where the nuts come from." Indeed, they continue to come mostly from the northern state of Para, where they grow wild in the Amazon jungle and are harvested by hand, as they always were, after they have fallen from the 100-foot high branches of *Bertholletia excelsa*.

Recent observers have not hesitated to compare the life of the *castanheiros* who gather these nuts to slavery. The work itself is miserable and hazardous. *Castanheiros* trek through the jungle barefoot on narrow trails. In the rainy season, they live in forest lean-tos for six months at a time, not knowing what their pay will be and steadily incurring debts for their subsistence at the company store.

What we call Brazil nuts grow in clusters of twelve to twenty-four, inside woody pods known as *ouricos* (or sea urchins) from their barbed outer shell. They weigh four pounds and when they plummet from on high, occasionally kill people.

In recent years, the export of these laboriously gathered nuts to their principal market, the United States, has brought Brazil millions of dollars in trade. This substantial commerce is now threatened, according to a recent Associated Press dispatch, by a jungle war over land rights. Twenty people were killed between the beginning of 1983 and fall of 1984. Plantation owners blame gangs of thieves who, they say, murder nut pickers and abscond with nuts and valuable wood. Local activ-

Matter of Taste

ts and priests claim the thieves are really e hired guns (*pistoleiros*) of the big ndowners, who pay them to terrorize nall farmers who grow their own food on nd the plantation owners claim is theirs. ve hundred settlers' homes have been urned. And the Brazil nut crop has re-ortedly fallen by 40 percent.

From the fragmentary and discordant vidence in this dispatch, it is not possible determine how this strife in the back ountry of the Amazon will ultimately af-ct the economic future of Brazil nuts. lanned cultivation and hybridization of ees is still in its infancy. The supply of ild nuts is very great. Labor has been ery cheap. And the long maturation pe-od of naturally occurring trees is twelve fifteen years, long enough to discourage ctive planting. One explanation for the urrent Brazil nut wars is that plantation wners have hired the *pistoleiros* to cut own their own trees so as to clear land, il-gally, for cattle raising. (Cheap land oncessions are available from the state nly for nut production.) These attacks on easants and primordial trees may be part f the general program of development nd deforestation of the Amazon.

Countless plants and animals are nreatened, not to mention indigenous hu-nan beings and their way of life. The tow-ring umbrellas of *B. excelsa* are particu-rly easy targets. Their nuts have been roduced and marketed in such a primi-ve manner that they can't really compete ith "modern" nuts that are sold shelled nd roasted. In the Amazon, cow meat is a etter bet per acre than nut meat.

In its own ecological niche, the Brazil ut tree has, however, found at least one consumer" group capable of dealing with s hard and tenacious hull. I'm thinking of

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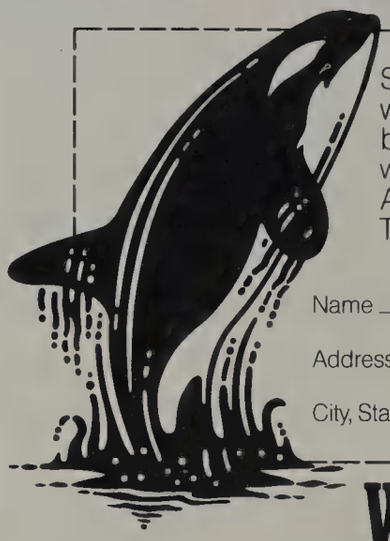

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certain fish in the Amazon that, according to the American-born researcher Michael Goulding, have evolved large molars and jaw muscles so that they can live off Brazil nuts that drop into their territory.

Human consumers are not so well provided for the challenge of the Brazil nut's flat-paneled brown shell. Even people strong enough to crack those shells with a conventional nutcracker discover more often than not that they usually cannot extract the white flesh from the shell without major efforts that risk pulverizing the flesh and lacerating the thumbs against the sharp corners of the cracked shell. This is the main reason that people leave Brazil nuts for last in a bowl of mixed, unhulled nuts. Another reason is that Brazil nuts cracked from the shell have a boring, starchy taste because they haven't been roasted.

This wrong-headed system of marketing is probably the result of history and poverty. Brazil has only recently acquired the packing technology necessary for the safe processing of Brazil nuts in tropical weather. I have been unable to find out if there are plans not only to shell but also to roast the nuts. Apparently, shippers are content to keep on sending dehydrated but raw nuts north, as they have for 200 years. But I am sure they would sell many more nuts if they roasted them.

Roasted Brazil nuts are delicious, far superior to raw nuts, just as roasted peanuts are superior to raw peanuts. You can test this proposition for yourself. Just a few minutes in the oven solve all the problems of the Brazil nut. The shells pop away from the flesh, leaving most nuts whole. And the flesh, turned an appealing brown right through, has improved immeasurably in taste (see recipe).

This process could, of course, be easily done on a commercial basis, if not in Brazil, then at the conventional port of entry for unshelled Brazil nuts at Mobile, Alabama. (The method generally used for Brazil nuts packed in cans of mixed nuts is gentler and does not bring out the flavor as well as roasting in the shell.) Perhaps some people are already doing this, but they must be operating in relative secrecy. For the most part, the historic Brazil nut industry is still sunk in its bad old ways, while the upstart macadamia growers have benefited from advanced science and merchandising right from the start. They are even enjoying a special boomlet now, during this period of excitement over all-American ingredients for so-called American *nouvelle cuisine*. I suppose it isn't so terrible if customers are made to think that macadamias are native American nuts, when they're Australasian. I like fish sautéed with macadamia dust as much as the next fellow. Ditto for macadamia ice cream. But I do think that it's time to put in a good word for a nut with a much longer history in this country, a nut that really does come from this hemisphere, that is cheap and at least as interesting in taste as a macadamia—after it's roasted.

Raymond Sokolov is a writer whose special interest is the history and preparation of food.

Brazil Nut Brittle

3 cups sugar
1 cup light corn syrup
2 cups roughly chopped, roasted Brazil nuts (see note)
4 teaspoons baking soda
1½ tablespoons butter
1½ teaspoons vanilla

1. Stir together the sugar and syrup with ½ cup water over high heat in a 6-quart saucepan. Continue cooking, without stirring, until the mixture reaches 240 degrees on a candy thermometer. The sugar undergoes various changes in its crystal structure as its temperature is raised. Some changes take longer than others. Do not give up when the mixture seems determined not to heat up further after it reaches the boiling point. When it does attain 240 degrees, the mixture is at the "soft ball" stage, so called because cooks without thermometers learned that at this temperature (identified with exactitude only later), sugar mixtures would make a soft ball when immersed in cold water.
2. Add the Brazil nut fragments and continue cooking until the mixture reaches the "hard crack" stage, 300 degrees on the thermometer. Obviously, if you dropped some of the mixture into cold water at this point, it would turn brittle and glassy, hard and easy to crack.
3. Remove from heat and stir in the baking soda, butter, and vanilla. The mixture will bubble up dramatically at this point. This is why a large saucepan is recommended.
4. As soon as the baking soda has been smoothly incorporated, pour the brittle onto a greased marble surface or a large, greased jelly roll pan (or any metal pan with sides so that the brittle doesn't creep off the greased surface). Cool and then break into pieces. Store in a tin.

Yield: Two pounds

Note: Start with three pounds of unshelled Brazil nuts. Roast them on a baking sheet in a preheated 400-degree oven. After 15 minutes, test a nut with a nutcracker or pliers. It should crack with relative ease, and the nut should emerge whole or in two large pieces, nicely browned. If this does not happen, continue roasting a few more minutes. Crack nuts immediately after roasting. You will probably get more than you need for the recipe this way, but it is difficult to predict in advance what the yield in nutmeats per pound of unshelled nuts will be.

Macadamia Nut Brittle

Adapted from *The Simple Art of Perfect Baking*, by Flo Braker (William Morrow and Co.)

Oil
3 ounces unsalted macadamia nuts (see note)
¼ teaspoon baking soda
½ cup (100 grams) granulated sugar
1 ounce (2 tablespoons) unsalted butter

1. Using a paper towel, spread a thin film of unflavored vegetable oil on a baking sheet; set aside.
2. Pour the nuts into a food processor fitted with a steel blade and process with off/on bursts until they are coarsely chopped. You should end up with ¾ cup. (It is also possible to chop the nuts with a chef's knife on a cutting board.) Pour into a small bowl, sprinkle with the baking soda, and toss briefly just to combine.
3. Pour ¼ cup (2 ounces) water, then the sugar, into a 5-cup copper sugar pot or a 1-quart, heavy-bottomed saucepan, and place over low heat. Swirl to moisten the sugar. Heat until the sugar dissolves. Add the butter, raise heat to medium, and boil the mixture until it registers 280 degrees on the candy thermometer.
4. Remove from heat, immediately add nuts, and stir briefly just to combine. The mixture will foam because the heat activates the soda, which lightens the brittle's texture. (Too much stirring will deflate the brittle.) Pour the mixture onto the baking sheet. Set aside to cool and harden. When the brittle is completely cool, store it in an airtight metal container for up to 1 month at room temperature.

Note: Unsalted macadamias may be found at health food stores. If only salted nuts are available, toss and roll them first in a dry towel, then in a damp towel. Spread them in a thin layer on a baking sheet to air dry for a few hours. Cashews may be substituted for macadamias.

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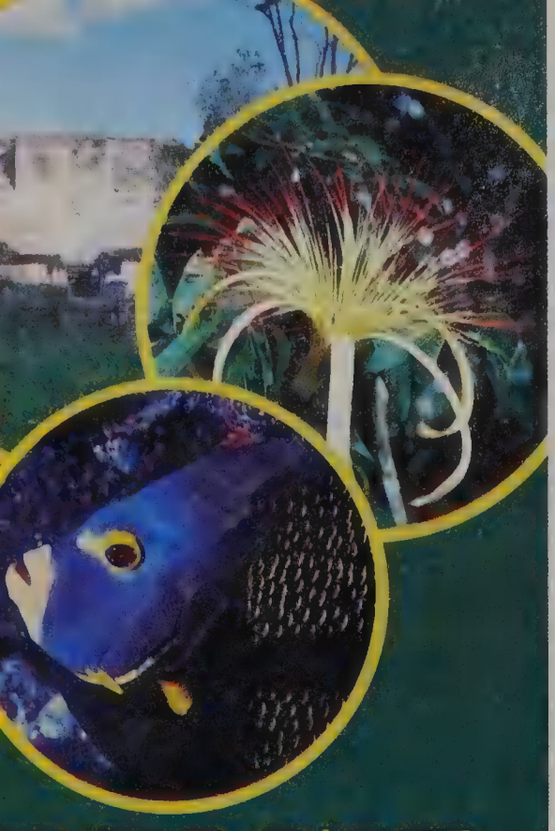

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Hercules Glade, Missour

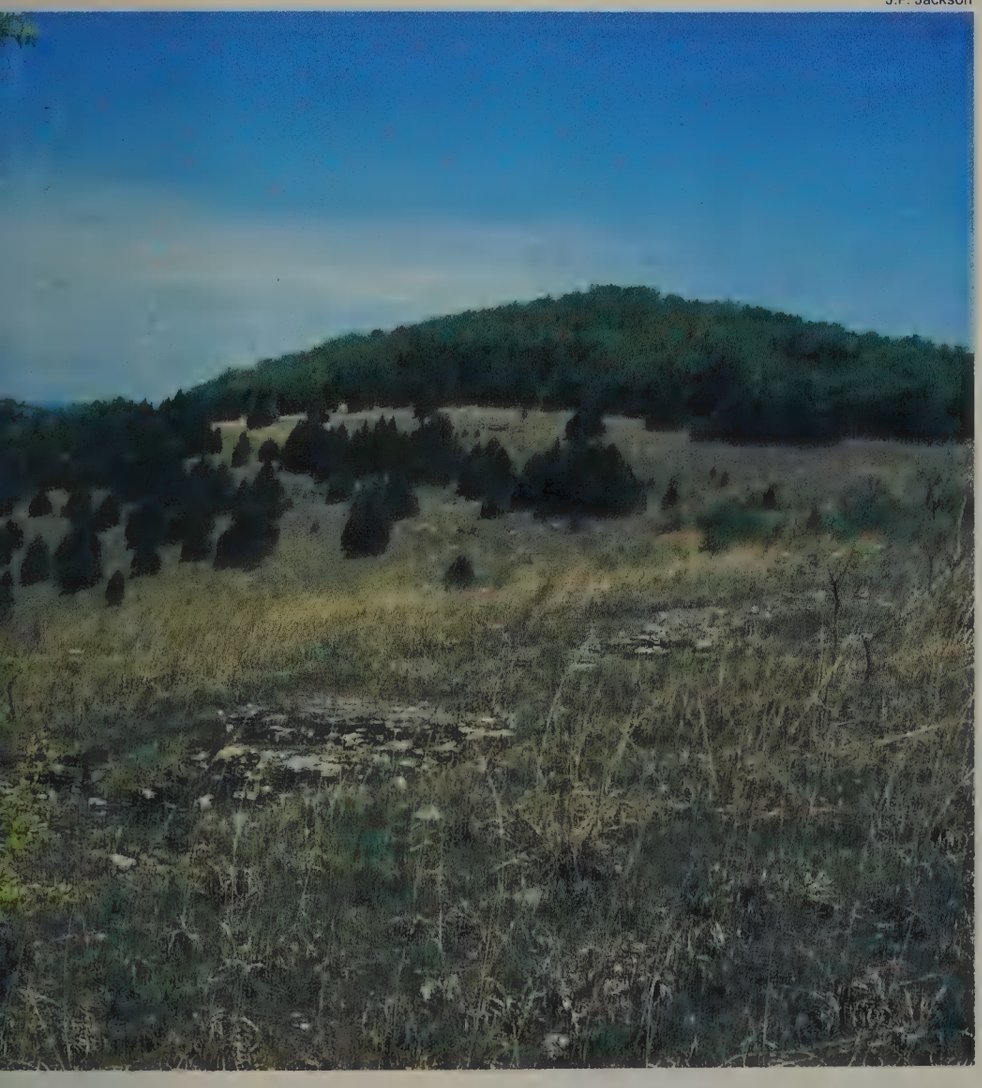
by Robert H. Mohlenbrock

Some people call them balds or knobs, while others refer to them as barrens. I prefer glade, which I define as a forest opening strewn with exposed rocks. There are hundreds of glades in the Missouri Ozarks, ranging in size from a few hundred square feet to several hundred acres. Although most glades are surrounded by dense, oak-dominated forests, there is little encroachment by the trees. For one thing, the soil in the glades is not nearly deep enough for oaks. For another, most glades face south and west, and the hot summer sun strikes them directly, creating an arid and generally inhospitable habitat. Not even summer thundershowers moisten the ground; the water runs rapidly off the shallow soil.

A few trees do grow where pockets of soil have accumulated in the glades. Red cedar is common, being able to survive the dry conditions because of its diminutive, needlelike leaves, which lose little moisture through evaporation. Less usual are two small trees whose roots deeply penetrate the cracks in the rocky substrate to reach the limited supply of water: the smoke tree, with its blue-gray fruiting sprays, and the fringe tree, with its pendulous clusters of white flowers.

To thrive in the glade environment, plants must compensate for the lack of moisture between June and September. Annuals complete their life cycle in a short time, then rely on their seeds for their perpetuation the following year. Most do not take the trouble to survive the summer. The dwarf leavenworthia mustard, for example, germinates in late autumn, overwinters with a tiny cluster of leaves, flowers in late March, forms its seeds by early May, and then dies back before the heat of the summer. The slender-leaved heliotrope, on the other hand, usu ally germinates in June, flowers in July and August, and forms its seeds in Sep tember. While this may seem like a poo strategy, the plant thus takes advantage o a niche left by the annuals more typical o the glades. As a compensation, this helio trope's very narrow leaves control wate loss. With the rising temperatures of sum mer, the edges of the narrow leaves roll un

J.P. Jackson



and inward, exposing even less area to sun's rays.

Perennials have to survive the entire owing season to build up enough food reves, mostly starches, to last the winter d produce new leaves the next spring. nnuals generally require fewer reserves form their seeds.) To cope with midmmer conditions, flower-of-an-hour and se aloe have thick fleshy leaves for storing large quantities of water. Prickly pear cactus retains excess water in fleshy, padlike stems; there is no water loss from its leaves, which are modified into spines. The leaves of wild petunia are covered with a dense entanglement of hairs, a barrier against rapid evaporation of water. The food reserves of the Missouri black-eyed Susan accumulate in thickened stems just beneath the surface of the soil,

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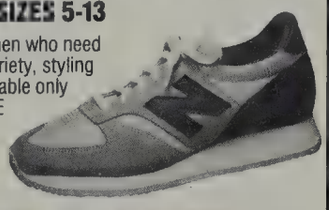
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In the Ozarks, glades are distinguished by rock type, and rock type affects the vegetation. Centered in southern Missouri and northern Arkansas, these mountains constitute one of the oldest exposed geological regions in the world. A billion years ago, a thick lava flow covered the area. After it had cooled, a great mass of molten rock thrust upward, melting and absorbing some of the lava in its way. The molten rock cooled very slowly, forming a coarse-grained granite. After eons of erosion, this granite dome eventually sank beneath the sea and was covered by several thousand feet of sedimentary limestone and sandstone. Two subsequent movements, one 400 million years ago and another more recently, again raised the region's rock mass. Since then, erosive forces have continued their work. In places, the limestone and sandstone have been worn away, leaving the ancient granite exposed; elsewhere, sandstone or limestone dominates.

Perhaps the most pristine of all the glades is Hercules Glade in southwestern Missouri. It lies in a 12,000-acre wilderness of the same name administered by the Mark Twain National Forest. Hercules is a limestone glade; what little soil it has averages only about four inches deep.

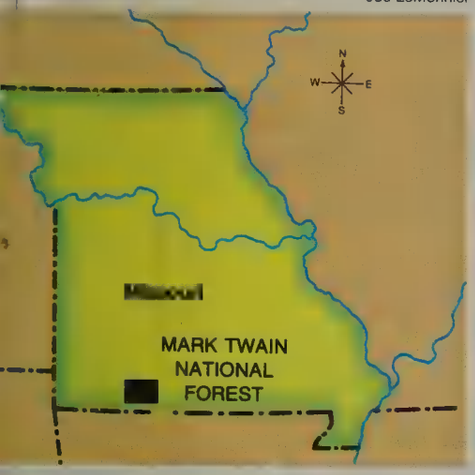
During winter and early spring, the glade is uncharacteristically wet, ofte with shallow pools of standing water, b cause of abundant rain and snow. There less evaporation because of the higher hu midity. May brings a combination of giar purple-flowered beard-tongue (penste mon), whose tubular flowers measur more than two inches long and are nearl as broad; blue false indigo, with densel packed elongated clusters of flowers; an Missouri evening primrose, whose brigh yellow, saucer-sized flowers conceal th rest of the plant.

In summer, lack of rain, rapid drainage and maximum evaporation create des ertlike conditions in the glade. Plants tha persist into summer often wilt, and an mals either burrow into the shallow soil o retreat into the surrounding forest. Ther is a lull in the blooming of wildflowers while dense stands of tall grasses give Her cules Glade the look of a prairie. Big an little bluestem, prairie dropseed, India grass, and side-oats grama, all characteris tic plants of the prairies of Kansas and Ne braska, dominate the scene. Seeds of thes grasses, which probably arrive by way o the frequent, strong westerly winds, hav a good chance of germinating in the ab sence of competition from shade-formin trees. In late August and September, th glade again becomes a sea of color—or ange Missouri black-eyed Susans, cylin drical violet spikes of blazing stars, an

The Missouri evening primrose blooms in May. J.P. Jackso

Hercules Glade

Joe LeMonnier



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owded purple heads of the daisylike
lafoxia.

Although the plant life is the star at-
action of Hercules Glade, the animal life
also intriguing because of its western af-
nities. The scissor-tailed flycatcher can
e seen on occasion, an attractive bird that
not uncommon in Oklahoma but just
rely gets into Missouri. The gawky
adrunner, better known from Arizona,
pparently arrived in southwestern Mis-
uri about 1956, spread to many glades,
d then started to decline after the rigor-
s winter of 1976–77. Another western
imal that sometimes races at high speed
er the rocky terrain is the collared liz-
d, a pugnacious, foot-long reptile readily
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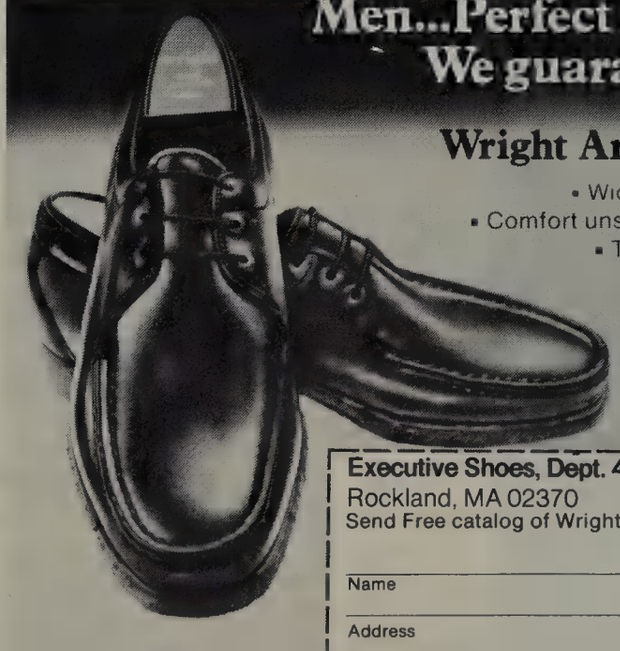

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The Morning Sky Gets Better and Better

by Thomas D. Nicholson

During early March, Venus, still brilliant and well placed in the evening sky, is joined by Mercury in a favorable elongation. Any evening that you can see Venus, from the 10th to the 20th, look below it and to the left. If you see another star, it can only be Mercury. After Venus begins its retrograde motion on the 12th, however, it rapidly loses the advantage of its height above the horizon. Mercury, unfortunately, dims swiftly after the 10th. Both will be gone from the evening sky by late March.

The planetary scene, so much a part of the evening sky this past autumn and winter, now shifts noticeably to the morning. Saturn and Jupiter are already there, the latter brighter and easily seen in the southeast at dawn all month. Saturn rises before midnight and looks ever so much like a twin star to Scorpio's Antares during the early morning hours. The moon helps you find them on the morning of the 12th. Venus's swift disappearance in the evening presages its equally swift appearance to the sun's right, where it will become an excellent morning star by late spring.

The following events occur at local times unless otherwise indicated.

March 1: The moon is only one day past first quarter at the beginning of March, visible in Gemini until it sets after midnight. The two bright stars to its left are Pollux and Castor, while Aldebaran, in Taurus, is to its right and below.

March 2–3: The fattening gibbous moon moves out of Gemini and into Cancer, passing from right to left below Gemini's "twin" stars, Pollux and Castor.

March 5: The crescent moon is in Leo, about where the Lion's heart should be. The star below it is Regulus, Leo's brightest, and the circle of stars above Regulus forms the Lion's head. A triangle of stars to the left marks the Lion's haunch and tail, with the star Denebola at the end of the tail.

March 6: Full moon occurs at 9:13 P.M., EST, in Leo.

March 7: Saturn, now up by midnight, is stationary relative to the stars and begins to move westward (retrograde). It has been drifting to the east through Libra, but it won't make it into Scorpius until late in the year. For the next two months, Saturn moves away from Scorpius, back into Libra.

March 8: Perigee moon (nearest the earth) is in Virgo, near its brightest star, Spica.

March 11–12: The gibbous moon rises close to Saturn about midnight and moves up the sky with it on the morning of the 12th. Both are high in the south before dawn. The reddish star below the moon is Antares, in Scorpius.

March 12: Venus is standing still against the background of stars just before it begins to come between the earth and the sun. Now its westerly (retrograde) motion takes it quickly toward the sun and out of the evening sky.

March 13–14: Last-quarter moon is at 12:34 P.M., EST, on the 13th. On the morning of the 14th, the rising moon is in Sagittarius, with the stars of the "teapot" below it.

March 17: Jupiter is the bright object near the rising crescent moon this morning. Both are in Capricornus. The moon passed from right to left below Jupiter at about 9:00 P.M., EST, on the 16th. Mercury reaches its greatest separation to the left of the sun today (greatest easterly elongation), its best position this season as

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an evening star. March evening elongations are favorable, so the opportunity of seeing Mercury low in the west after sundown should be good, even though its brightness is now diminishing.

March 19: This is the last morning to see the late crescent moon in the dawn sky before it becomes new in a few days.

March 20: The sun arrives at the vernal equinox (where it crosses the equator from south to north) at 11:14 A.M., EST, and spring begins in the Northern Hemisphere. The sunrise-sunset tables identify March 17 as the date on which day and night are of equal length in the mid-northerly latitudes. Refraction by the atmosphere explains most of the difference.

March 21: New moon is at 6:59 A.M., EST, in Pisces, very close to the vernal equinox.

March 22: At sundown tonight, you may have a chance of seeing the very slender crescent moon. Although it is only about a day and a half old, it is steeply up the sky relative to the sun. Should the western sky be clear enough to see the moon, look to its right for Venus, a bit higher, and Mercury, dimmer than Venus and about halfway between that planet and the moon. Both planets were in conjunction with the moon earlier today and with one another at about 9:00 P.M., EST.

March 23: Apogee moon (farthest from the earth).

March 23–24: The crescent moon i easily visible these nights, close to Mars which is about as bright as Hamal, in Ar ies above them. Mercury begins its retro grade motion on the 24th.

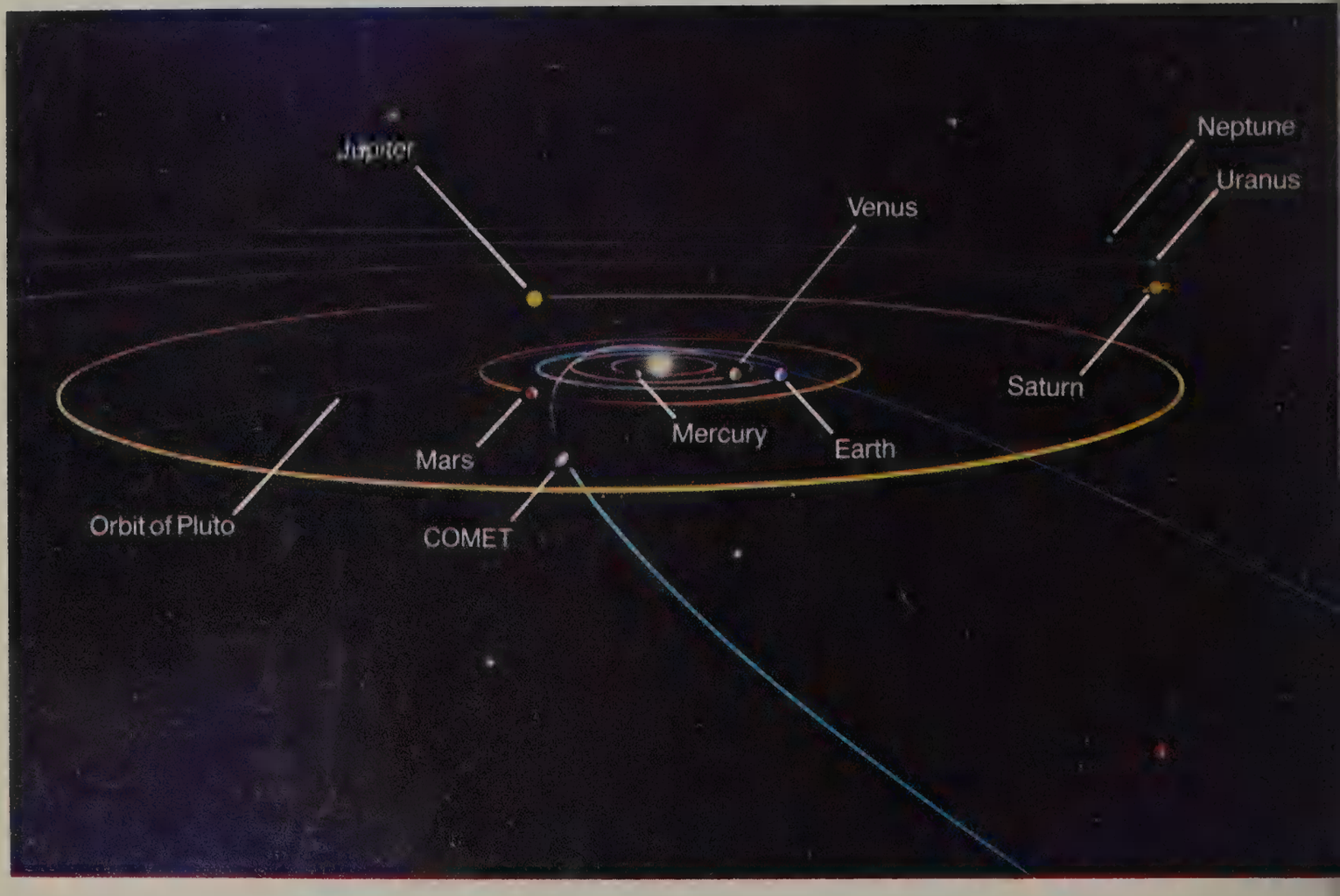
March 26–30: The waxing moon move past the bright stars of Taurus and Gem ini. First-quarter phase is at 11:11 A.M. EST, on the 29th.

March 31: The moon is in Cancer, mid way between Gemini's two bright stars Pollux and Castor, and Leo's Regulus.

Editor's Note: The Sky Map in the Janu ary issue shows the evening constellation and stars for this month and gives the dates and times for use.

Halley's Comeback

Helmut Wimme



This month, our view of Halley's comet is oriented as it was in February, from beneath the plane of the planets, looking up at them. But we have focused in closer to the inner planets, to illustrate in greater detail the comet's path as it approaches them. On this scale, we can show more clearly the movement of the comet for several more months. The illustration shows the location of the planets—from Jupiter inward to Mercury—in their orbits, with the comet's orbit tilted up toward them. The position of Halley's comet is again represented by a small cometlike image on its elongated orbit, even though no visible structure has yet developed. Still well south of the solar system's main reference plane (the ecliptic), the comet is moving steadily northward toward the ecliptic as it moves closer to the sun. It is now closer to the sun and to the earth than is Jupiter's orbit, but is still fa away from the inner region of the sun's realm, where the four ter restrial (earthlike) planets—Mars, Earth, Venus, and Mer cury—cluster together. During March, Halley's comet move 28 million miles closer to the sun, accelerating slowly as it ap proaches perihelion (the point nearest the sun). On March 9 when it is eleven months away from perihelion passage aroun the sun, the comet will have moved in to about 430 million mile from the sun. In that part of the sky visible from the earth, th comet is located in the constellation Taurus, still well above ou western horizon during March evenings. But it remains far to dim for us to see. Later in the year, when chances of seeing it ar better, "Celestial Events" will locate it in greater detail.

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That Ultrafright Smile

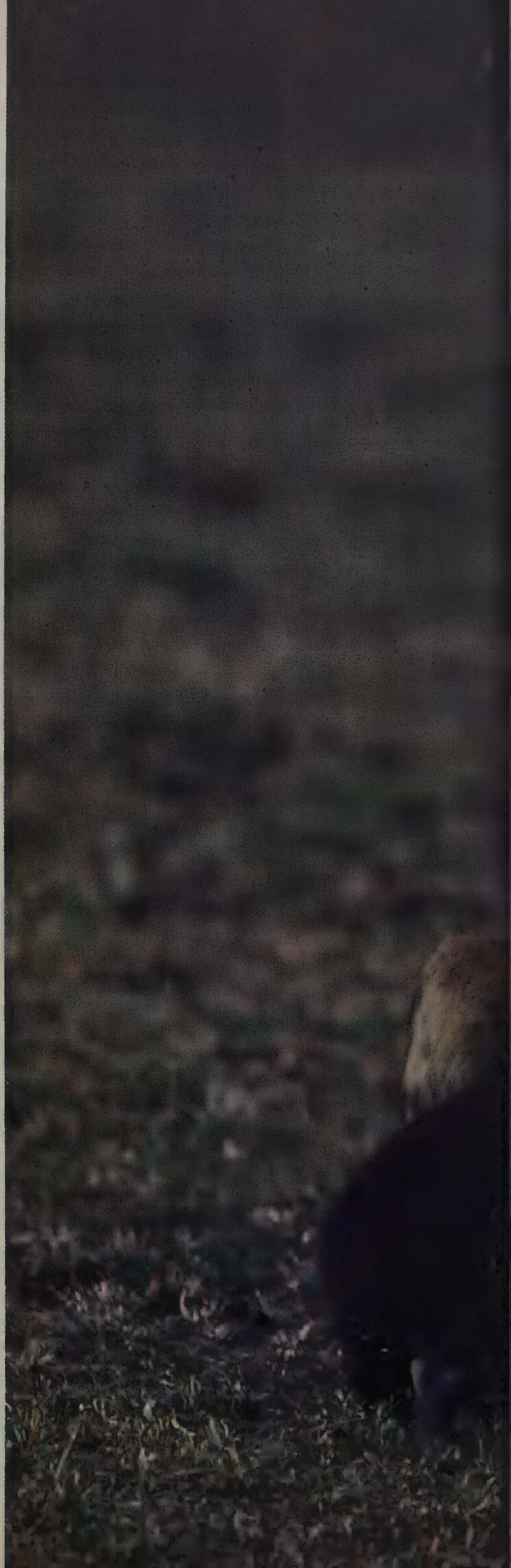
John Shaw came across this spotted hyena on Masai Mara, Kenya's national game reserve, while leading a group of amateur photographers on their first big game shoot. When he stopped his vehicle and got out, the hyena noticed him and sat down. Her two young cubs immediately dove for her nipples. Judging from the vegetation in the area, and the several hummocks near her, the den was probably nearby. So Shaw ordered his students out, knowing they were reasonably safe.

It's never wise to make a spotted hyena nervous. Among the deadliest of African predators, they can eat and digest whole carcasses, including skin and bones. The spotted hyena, which can hunt individually or in groups, feeds mainly on ungulates such as wildebeest or zebra, but there have also been fatal attacks on humans. Ernest Hemingway once referred to the hyena as the "biter-off of your face" in the night.

Spotted hyenas breed all through the year, and females usually have a litter of two, occasionally one or three. The cubs are nursed for twelve to sixteen months, at which point they are almost their adult size. Males reach sexual maturity at age two, females at age three. The animals live in large clans, with up to eighty individuals. These are made up, in turn, of subgroups containing two to ten hyenas.

It was near sundown when Shaw and his group came upon this family. To make matters worse, a storm was moving into the area. He didn't know if there was sufficient light to get the picture. But he did have one lens that he knew could work. It was a fast 400-millimeter, and setting it at f/3.5 gave him an exposure time of one-sixtieth of a second. Still, he wasn't happy about the setup because the hyena kept shifting position as the mouths on her shifted.

But then she did something wonderful. She yawned, a big, horrible yawn that showed those teeth that can crunch through a heavy bone. "Great," Shaw said, squeezing off three shots before the hyena closed her mouth.—*D.W.*



Photograph by John Shaw

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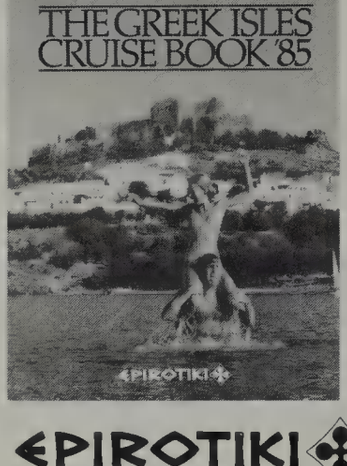

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Additional Readi

Breadfruit (p. 34)

In 1787 H.M.S. *Bounty* set sail fron England bound for Tahiti, with Capt. Wi liam Bligh in charge. Its mission was t transport breadfruit trees to the Britis colonies, but constant storms, low food ra tions, and Bligh's harsh temper made th journey long and difficult. *Mutiny on th Bounty,* by C. Nordhoff and J.N. Hal (Boston: Little, Brown and Co., 193 many publications since), chronicles th voyage to Tahiti, the crew's stay on the is land, and the historic return journey, dur ing which Bligh and eighteen loyal sea men were cast off in an open boat. Thre films have been made about this famou mutiny. The first, *Mutiny on the Bount* (1935), starred Charles Laughton as Cap tain Bligh; Trevor Howard was Bligh i the second version (1962). Bligh's princi pal antagonist, Fletcher Christian, wa played by Clark Gable in the first film an Marlon Brando in the second. *The Bount* (1984) featured Anthony Hopkins a Bligh and Mel Gibson as Mr. Christian Lord Byron wrote a poem about the leg endary mutiny, "The Island; or Christia and his Comrades" (see *The Complet Poetical Works of Byron,* Boston: Hough ton Mifflin Co., 1933), based on Willian Bligh's *A Narrative of the Mutiny an Seizure of the Bounty, in the South Seas in 1789.* Captain Cook much admired th breadfruit; during his long South Sea voy ages, he reduced the incidence of scurv among his sailors by making breadfruit a essential part of their diet. See his writing about the breadfruit in *The Journals o Captain James Cook,* edited by J.C Beaglehole (New York: Cambridge Uni versity Press, 1955). The letters of Josep Banks, the prominent British naturalis who accompanied Cook on his first expe dition, are in the collections of the Britis Museum and have been edited by W.R Dawson: see *The Banks Letters* (London The British Museum Publications, 1958) J.M. Purseglove summarizes the botan of the breadfruit in *Tropical Crops: Di cotyledons* (New York: John Wiley an Sons, 1968). On a lighter note, Na Lim Kokua, the Helping Hands of the Pacifi Tropical Botanical Garden, publishes

xteen-page booklet containing thirty-ree breadfruit recipes. *Breadfruit (Ulu): ses and Recipes* is available for $2 from a Lima Kokua, Pacific Tropical Botani-l Garden, P.O. Box 340, Lawai, Kauai, awaii 96765.

hickadees (p. 42)

In winter, flocks of chickadees are ade up of two sorts of birds: those that ay in a single flock (the regulars), and ose that move from one flock to another he floaters). S.M. Smith investigates the tricacies of the flock status system and e breeding strategies behind it in "Flock witching in Chickadees: Why Be a Win-r Floater?"(*The American Naturalist,* ol. 123, pp. 81–98). Smith also looks at e roles of floaters in "The 'Underworld' a Territorial Sparrow: Adaptive Strat-gy for Floaters" (*The American Natu-alist,* vol. 112, pp. 571–82). Also interest-g is J. Ekman, G. Cederholm, and C. skenmo's "Spacing and Survival in Win-r Groups of Willow Tit *Parus montanus* nd Crested Tit *P. cristatus*—A Removal tudy" (*Journal of Animal Ecology,* vol.), pp. 1–9). For a concise account of nickadee natural history, see part II of .C. Bent's classic *Life Histories of orth American Jays, Crows, and Tit-ice* (New York: Dover Publications, 964). N.B. Davies's "Ecological Ques-ons About Territorial Behaviour" forms napter 11 of *Behavioural Ecology,* lited by J.R. Krebs and Davies (Sunder-nd, MA: Sinauer Associates, 1978, pp. 7–350).

acandon Maya (p. 50)

This issue's article on the Lacandon is xcerpted from *Gertrude Blom*, edited by . Harris and M. Sartor (Chapel Hill: niversity of North Carolina Press, 984). This is a collection of 104 black-nd-white photographs of Indian tribes in e Mexican rain forest, taken by Blom er a forty-year period. Essays by Blom nd others offer insight into her life and ork and also discuss the Maya of Chia-as and the destruction of tropical rain rests. A good description of the rain for-ts and the people who live in them, geared for a popular audience, is *Jungles,* edited by E.S. Ayensu (New York: Crown Publishers, 1980). Several chapters of *The Sinking Ark,* by N. Myers (New York: Pergamon Press, 1979), are devoted to the problems of plant and animal extinctions in tropical rain forests. *In the Rainforest*, by C. Caufield (New York: Alfred A. Knopf, 1985), describes how aboriginal peoples are being driven out of their homes in the rain forest because they stand in the way of "progress." An excerpt appeared in the January 14, 1985, *New Yorker. Technologies to Sustain Tropical Forest Resources* (Washington, D.C.: U.S. Congress, Office of Technology Assessment, OTA-F-214, March 1984, Government Printing Office Stock Number 052-003-00943-9) is a collection of papers on the status and future of the world's tropical forests. This well-documented, 344-page volume is available in paperback from the U.S. Government Printing Office for $10. For a free 35-page booklet summarizing the report, write to the Congressional Relations and Public Affairs Office, Office of Technology Assessment, U.S. Congress, Washington D.C. 20510. F. Blom and G.D. Blom briefly survey all aspects of Lacandon Maya life in "The Lacandon," in *Handbook of Middle American Indians,* vol. 7, edited by E.Z. Vogt (Austin: University of Texas Press, 1969, pp. 76–97). The earliest, but still the most complete, ethnographic study of traditional Lacandon culture is A.M. Tozzer's *A Comparative Study of the Mayas and the Lacandones* (New York: Macmillan Co., 1907; reprinted in 1978 by AMS Press, New York). V. Perera and R.D. Bruce study cultural changes in the Lacandon Maya settlement of Najá in *The Last Lords of Palenque* (Boston: Little, Brown and Co., 1982). The effects of economic development on South American Indians are explored in S. Davis's *Victims of the Miracle* (New York: Cambridge University Press, 1977). A number of organizations are active in the fight to protect the rights and environments of the world's indigenous peoples; the following three publish either a journal or periodic newsletters or bulletins: Cultural Survival, 11 Divinity Avenue, Cambridge, MA 02138, publishes *Cultural Survival Quarterly;* Anthropology Resource Center, P.O. Box 152266, Washington, D.C. 20003-0266, publishes *The Global Reporter: A Journal of People, Resources, and the World;* and Survival International, 29 Craven Street, London WC2N SNT, England, publishes frequent action bulletins for its members (the U.S. branch is located at 2121 Decatur Place NW, Washington, D.C. 20008).

Foraminifera (p. 60)

Most introductory geology and paleontology textbooks contain some information about foraminifera and their history on earth. For example, J.R. Beerbower's *Search for the Past* (Englewood Cliffs: Prentice-Hall, Inc., 1969), an introduction to paleontology, devotes about ten pages to the forams. Oceanography texts are also helpful, particularly for data on planktonic forams. Some scientific articles on these tiny creatures include: "All About Ooze," by N. Rosa (*Oceans,* November 1979, pp. 30–33); "Neglected Amoebas in Culture," by J.J. Lee and H. Freudenthal (*Natural History,* December 1963, pp. 54–61); and "Corals and Coral Reefs," by T.F. Goreau et al. (*Scientific American,* August 1979, vol. 241, pp. 124–36). Although there are many more recent articles on mass extinctions, N.D. Newell's "Crises in the History of Life" (*Scientific American,* February 1963, pp. 76–92, also reprinted in *Scientific American Resource Library Readings in the Earth Sciences,* vol. 2, published by W.H. Freeman, New York, 1969) is known for the comprehensive range of organisms that it covers. Finally, see "Science and the Citizen: Seven Hypotheses" (*Scientific American,* April 1982, p. 80) for a short explication of Mesozoic mass extinctions.

Rita Campon

Erratum: In the August 1984 issue, *Natural History* failed to mention that the fossil ammonite specimens shown in photographs on pages 34–35 and 37 were from the Yale Peabody Museum.

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Authors

Some of the projects **Gerald Oster** and **Selmaree Oster** (page 34) have worked on in Haiti are symbolized in their "photo," actually an eighteen-inch-diameter papier mâché plaque by the Haitian mask maker Lionel Simonis. Gerald Oster holds a goat to illustrate a program of confining farm animals to pens, important in Haiti, where overgrazing by farm animals causes devastating soil erosion. The Peking duck in Selmaree Oster's arms relates to a fish farming project. Pisciculture can provide desperately needed protein to the Haitian population, and duck droppings fertilize the pond algae on which the fish feed. The Osters' main medical project in Haiti consists of developing a botanical approach to eliminating the region's malaria-carrying mosquito. They have also

worked jointly in reproductive biology at the Mount Sinai School of Medicine of the City University of New York, where they discovered a method for detecting signs of impending human ovulation.

Susan M. Smith (page 42) says, "I became a rabid bird watcher at the age of nine when I saw a golden-crowned kinglet on my way to school." Chickadees, the subject of her article in this issue of *Natural History*, captured her interest because they are one of the few common winter songbirds in Winnipeg, Manitoba, where she was born and spent her early childhood. Smith is currently an associate professor in the Department of Biological Sciences at Mount Holyoke College in South Hadley, Massachusetts. She did her undergraduate work at the University of British Columbia in Vancouver and received a doctorate in zoology from the University of Washington in Seattle. Among her free-time activities, Smith lists cross-country skiing; she points out, however, that although she enjoys the sport, she is emphatically a neophyte.

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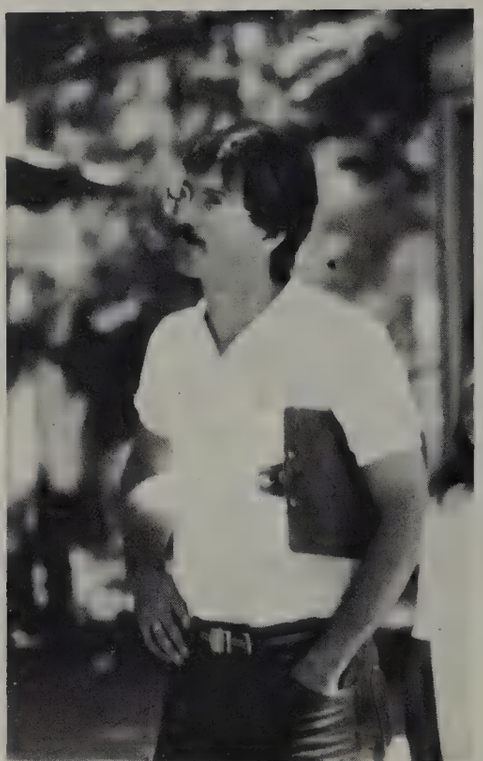
Authors, continued

"I first went to Chiapas, Mexico, in 1974 to study the population ecology and rain forest agriculture of the Lacandon Maya and soon realized that their rain forest environment was literally being burned into extinction—the Lacandon Maya were a forest people soon to be without a forest," explains **James D. Nations** (page 50). "I was determined to study ways to avoid that destruction." In 1979, Nations returned to explore indigenous agricultural systems as alternatives to beef cattle production, the major cause of rain forest destruction in Mexico and Central America. Since the fall of 1981, he has been a senior researcher with the Center for Human Ecology, an independent environmental research and consulting group in Austin, Texas, that focuses on the Latin American tropics. Nations earned his doctorate in anthropology from Southern Methodist University.

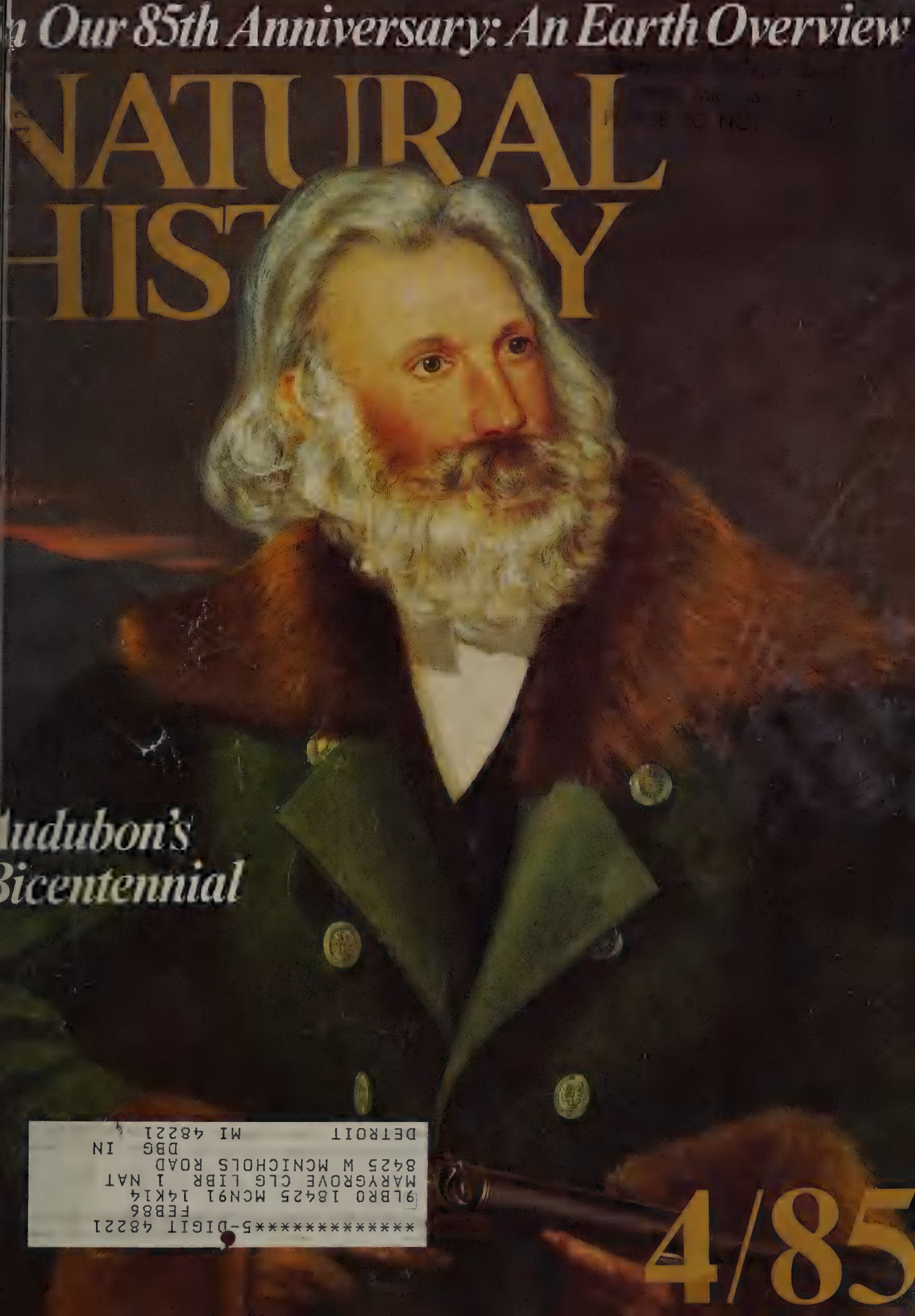


"I am not an English teacher," insists **John Shaw** (page 90), even though nobody said he was. Sixteen years ago Shaw, who had been insisting that to himself for some time, decided to scrap his college teaching career (American literature—transcendentalism) and pursue wildlife photography. And every now and then, he still doesn't mind clarifying what he is not. "I *was* an English teacher," says Shaw, "who either went good or went bad, depending on how you look at it." Lots of magazines think he went fine. Shaw has published in *Audubon*, *National Wildlife*, and a stack of others. Last year he published *The Nature Photographer's Complete Guide to Professional Field Techniques* (New York: Amphoto), and for the past few years he has been holding summer workshops in Kenya on big-game photography. If these last two credits sound of the pedantic sort, they probably are. But, as Shaw would point out, they are not English teaching credits, a difference that has made all the difference.

"Whether standing on a rock outcro
diving on a coral reef, leading studen
on a field trip, looking through a micr
scope, canoeing on a river, backpackin
in the mountains, watching birds,
playing with my cats, I am fascinated b
the history of life on Earth," says **Pame
Hallock** (page 60). Born in South D
kota, she gets around. She earned h
B.A. from the University of Montan
her Ph.D. from the University of H
waii, did postdoctoral research at Ki
University in the Federal Republic
Germany and the University of Cope
hagen in Denmark, and has conducte
field studies in Palau in the western P
cific, Hawaii, Micronesia, Mauritiu
the Seychelles, Kenya, the Gulf of Eil
on the northern tip of the Gulf of Aqab
the Florida Keys, the Bahamas, Beliz
Grand Cayman Island, and Puerto Ric
"After eleven years of work with mode
foraminifera,"she adds, "I undertook
study of some twenty-million-year-o
fossil foraminifera, and my research le
me to wonder why those ancient forn
were so much more complex than mo
ern species."

n Our 85th Anniversary: An Earth Overview

NATURAL HISTORY



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NATURAL HISTORY

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ATURAL HISTORY *(ISSN 0028-0712) is ublished monthly by the American Museum of Natural History, Central Park Vest at 79th Street, New York, N.Y. 10024. ubscriptions: $18.00 a year. In Canada and all ther countries: $23.00 a year. Second-class ostage paid at New York, N.Y. and at dditional offices. In Canada second-class ostage paid at Windsor, Ontario (permit no. 9579).*

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A Bite to Remember

One strike and you might be out, if you accidentally meet a viper in a rain forest

by Robert K. Colwell

After a long morning of research, my companion Bill Sheehan and I headed back to camp down a rain forest ravine in Corcovado National Park, a rugged wilderness in southern Costa Rica, where I had come to teach a course in tropical biology. I didn't see the snake until it was too late. As I jumped from one sand bar to another in the stream bed, I passed a buttressed tree, rooted about waist level in the stream bank. What I hoped was a thorn jabbed the biceps of my right arm, just below the short sleeve of my shirt. But then I saw twin slits in my skin, oozing yellow venom mixed with blood, and caught sight of a thick snake recoiling on the bank. I had always assumed that the strike of a large viper would hit like a fist studded with knives—not like the graceful, even gentle hypodermic pricking I had felt.

"Bill," I yelled upstream, "I've just been bitten by a *Bothrops atrox!*" I frankly have no idea why the Latin name came first to mind. The English name for this snake is actually French—*fer-de-lance*—for the shape of the head. The Spanish name, at least in Costa Rica, is *terciopelo*—"velvet"—for the rich black and tan colors and the sheen of the scales. The Latin name has officially been changed to *Bothrops asper* since I first learned it.

As Bill approached on the run, I had to divert him or he would have taken exactly the route I had followed, risking a second strike. By the time he arrived, I had removed the mesh bag of my insect net for him to tie as a constricting band above the bite on my arm, while I kept an eye on the snake. (A constricting band is a strip of cloth kept loose enough to insert one finger underneath it. The band must be released for ninety seconds every ten minutes to allow surface circulation. If bound so tightly that deep circulation is cut off, the band becomes a tourniquet—which can do more harm to a limb than a snakebite.) Then, breaking the rules, I ran a half mile to the park headquarters, rationalizing (incorrectly) that running would spread the poison only if the bite were in a leg. Bill stayed behind to kill the snake so it could be positively identified. I yelled for help as I passed the outdoor eating shelter at park headquarters, and the tables emptied.

During the next hour and a half I lay on a bunk in a park guard's room, not at all sure of my future. There was a great deal of scurrying about as three different sets of antiserums, with three conflicting sets of instructions in two languages, were gathered. My friend and fellow professor Barbara Bentley took charge, kept the rest of the course members busy and at bay, and began the sensitivity tests for horse-serum allergy on my left forearm.

To produce antiserum, or antivenin, horses are injected with sublethal doses of snake venom, inducing the formation of antibodies to venom proteins. Whole serum from the blood of these horses is reduced to a freeze-dried powder, which is easily reconstituted with sterile water when needed to treat snakebite. The production of snake antiserums is the responsibility of the Instituto Clodomirio Picado in San José, Costa Rica's capital city. Antivenins specific to local snakes are produced there and carried at all times during courses given in the field. The antiserums, one for vipers and one for coral snakes, are also readily available over the counter in drugstores throughout Costa Rica. While I waited the prescribed twenty minutes for the skin reaction test on my left forearm, which would determine if I could safely given antiserum, I watched my right a swell to twice its usual circumference a thought about all the things I am aller to—celery, watermelon, walnuts, poll guinea pigs . . . and horses (but not to th blood, I hoped).

Soon Bill came in to ask if I wanted see the snake, which he had killed wit machete after pinning it with a log. I s yes. It was in two pieces, the head seve from the four-foot-long body. I stared a and felt the weight of its thick body. It v a beautiful creature, wondrously adap for its life as a predator in ambush. Ha Greene, my colleague at the University California at Berkeley, has studied daily life of these snakes by carefu putting miniature radio transmitters do their throats and following their mo ments in the forest. The marvelously ca ouflaged fer-de-lance can sit motionless the same spot for days or even weeks, w ing for a meal to wander by.

Like other vipers, the fer-de-lance u not only its eyes but also special heat-se ing organs (known as pits, or Jacobso organs) to detect potential prey and to rect a strike. The venom injected in a s gle strike is enough to kill a victim the s of a large rabbit within minutes. Sna venom is extremely complex, vary greatly with the species of snake, its a and even its geographical origin. Unl the venom of coral snakes, fer-de-la venom has no direct effect on the nerv system but digests muscle, destroys blo cells, and causes hemorrhaging and m sive edema (swelling).

As I touched the body of the snake t bit me, I felt no rancor—only sorrow what must have been a case of mistal identity. The snake had struck from

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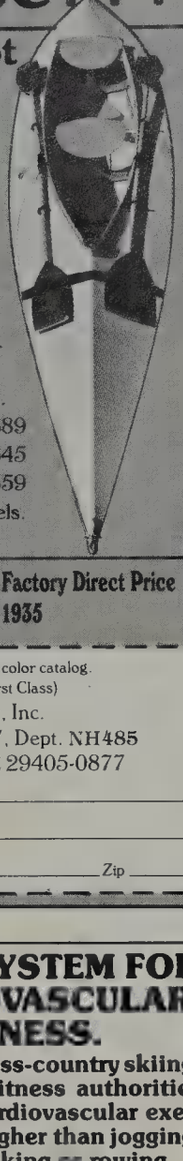

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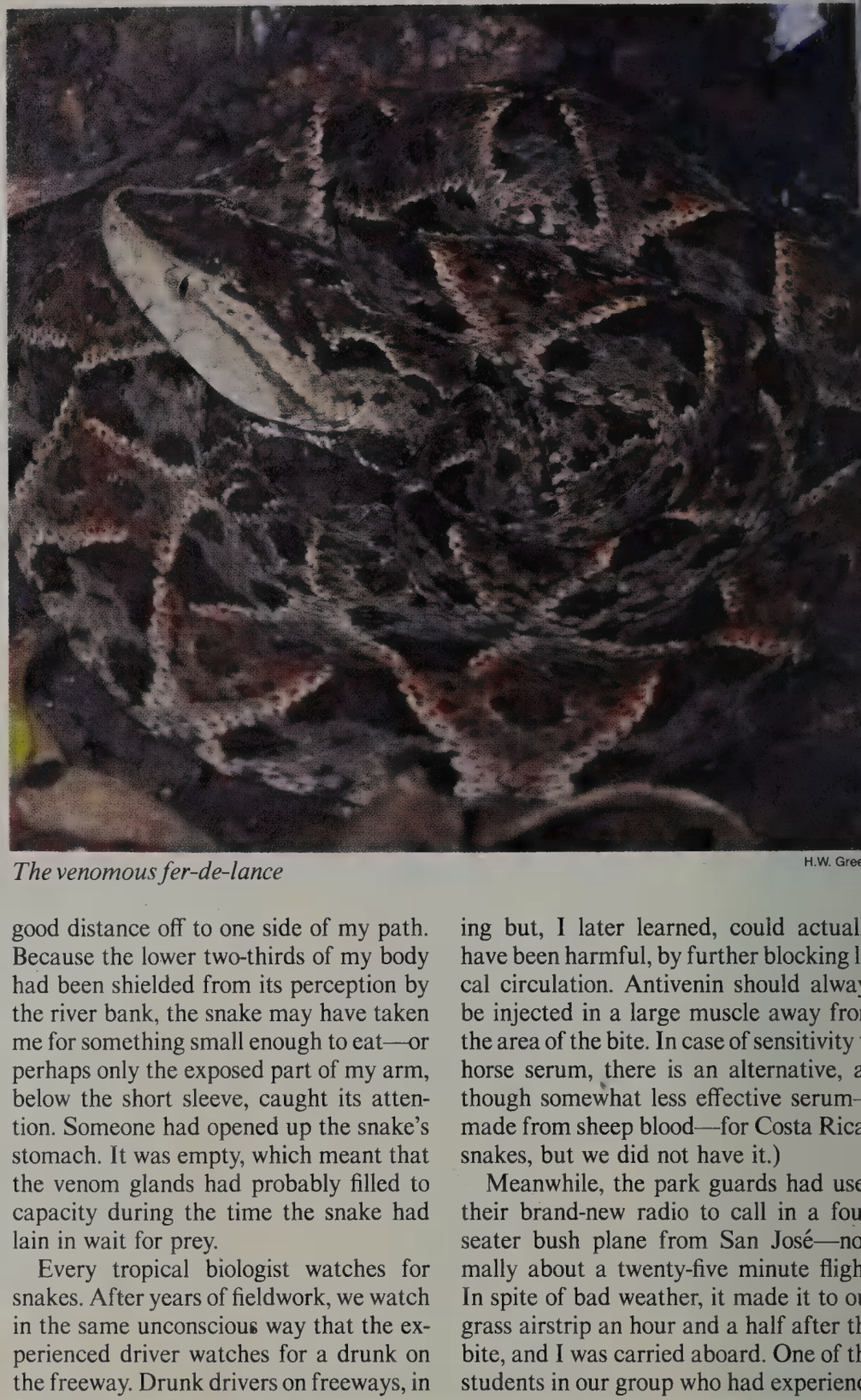

The venomous fer-de-lance H.W. Gree

good distance off to one side of my path. Because the lower two-thirds of my body had been shielded from its perception by the river bank, the snake may have taken me for something small enough to eat—or perhaps only the exposed part of my arm, below the short sleeve, caught its attention. Someone had opened up the snake's stomach. It was empty, which meant that the venom glands had probably filled to capacity during the time the snake had lain in wait for prey.

Every tropical biologist watches for snakes. After years of fieldwork, we watch in the same unconscious way that the experienced driver watches for a drunk on the freeway. Drunk drivers on freeways, in fact, are much more common than large poisonous snakes within striking distance in tropical forests. I calculate that one such snake is seen for every 400 to 800 person-hours in the field in Costa Rican rain forests. During the fifteen years of courses given there by the Organization for Tropical Studies, there were some 450,000 person-hours in the field without a venomous snakebite. Unfortunately, I had broken that record.

The antivenin allergy test was negative—I could safely receive the antivenin. My friends injected 30 cc into my backside and another 5 near the bite. (The injection in my arm was not only excruciating but, I later learned, could actual have been harmful, by further blocking l cal circulation. Antivenin should alwa be injected in a large muscle away fro the area of the bite. In case of sensitivity horse serum, there is an alternative, a though somewhat less effective serum- made from sheep blood—for Costa Rica snakes, but we did not have it.)

Meanwhile, the park guards had use their brand-new radio to call in a fou seater bush plane from San José—no mally about a twenty-five minute fligh In spite of bad weather, it made it to o grass airstrip an hour and a half after t bite, and I was carried aboard. One of t students in our group who had experienc treating shock accompanied me to Sa José, Adrenalin kit in hand. The flight w an ordeal. As the air pressure fell, the rel tive pressure inside my arm rose. We ha been at sea level, and San José is at 8,00 foot elevation, so landing didn't he much. Moreover, the air was choppy, ar substances in the venom that cause diso entation and nausea had taken hold. I w definitely losing control.

An elderly nurse greeted my entry in the emergency room at the hospital wi an intravenous rig. I was so near the end my rope that I must have let out a c when she put the needle in, because sh said sternly, *"Silencio, Señor! Esto es*

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hospital!" I vividly remember the remark because it forced me to get a firm grip on myself for the first time since boarding the airplane. Besides, it marked the moment when I began to feel that I actually would survive if I followed the orders of this crusty *comandante* of the emergency room. A huge dose of Demerol disappeared down the tube into my grateful body, followed by another 60 cc of antivenin, antitetanus serum, and several million units of penicillin. (One cubic centimeter of fer-de-lance venom contains about two million bacteria of a half dozen species, and tetanus is common on viper fangs.)

For the next three days I watched a dozen fellow humans come and go in the intensive care room, where I was kept because of the threat of bleeding. None of the other patients stayed for more than a day, and the only one who was conscious could not talk. In spite of the excellent care and facilities, a victim of a road accident and a man who suffered repeated heart attacks died as I watched. Then there was Alejandro, age sixteen, who had ruptured his esophagus while vomiting after drinking too much with some older friends. He was later to be my ward mate.

I think you are supposed to be unconscious when in intensive care. The lights were left on twenty-four hours a day and the staff chattered constantly to keep themselves alert and sane when nothing urgent was happening. I was grateful for my fluency in Spanish, but even so, I had difficulty getting anyone to tell me what was going on in my body or what dangers were keeping me in intensive care. Because my right arm was held in traction to keep the swelling down, I had to lie flat on my back under the fluorescent lights. From the wall clock I knew how much time had passed. There were no meals to punctuate those days, just changes of the glucose drip. Snake venom includes something that makes you too nauseated to hold even water down, let alone solid food.

No matter how unpleasant the nausea and how intense the pain, it is usually the "hemorrhagic fraction" of the venom of the fer-de-lance and related snakes that ultimately kills its natural prey and is responsible for most human fatalities as well. Victims bleed to death. The bleeding can be from internal organs (the staff in intensive care constantly checked my urine for the presence of blood) or from the eyes or ears—anywhere but from the bite itself, which is too swollen to leak from the tiny fang wounds. Rattlesnake venom, on the other hand, does not have much effect on the ability of blood to clot—hence the traditional recommendation to cut across the fang wounds and suck out the venom. It is mortally dangerous to cut anyone bi ten by a fer-de-lance or one of its relative of the genus *Bothrops*.

Despite the immediate and prope treatment with antivenin, the low platele count and the loss of certain clotting fac tors in my blood were sufficient to keep it clotting time eight times normal for th first day (hemophiliacs have a clottin time of about half that). Fortunately, sprang no leaks while my blood was heal ing, although the hospital staff was read for any emergency with appropriate drug on a tray at my side. However, the i.v. ha to be moved often to a new site because o local hemorrhaging; when there were n more usable veins in my left arm, my leg and even my feet were pressed into ser vice. I later discovered that an appeal ha gone out for O-negative blood, to matc mine.

My right arm continued to swell an discolor for two days; the swelling eventu ally included my right shoulder and th whole right side of my torso, and I coul no longer keep my head from tilting to th left. In addition to the clotting problem another concern was circulation to th lower part of my right arm—past the im mensely swollen area of the bite. Th pulse in my hand was checked every hou Had it weakened sufficiently, the doctor said they would have had to "make som deep incisions to release the pressure o the deep arteries" (a fasciotomy) to sav the arm itself. They told me it would b helpful to make a fist now and then. made a great many fists, and my puls stayed strong enough.

Moving from intensive care to a ward— with a real bed, real food, and lights tha went out at night—was like coming bac to Earth after spending three day strapped into a cramped spacecraf plagued with disasters. My arm was stil hoisted up on a rope, and there were stil frequent and ever more creative change of site for the i.v. tube, but I now ha peers, alive and awake, to talk to; visitor were allowed (first, my wife, Mary-Claire who had come from California, and late other friends); there were meals, sunrise and sunsets, and at last, the swelling wa beginning to subside. Alejandro of th ruptured esophagus was already there complaining about the bland liquid diet h was allowed. His friends smuggled i small cans of fruit juice, cookies, an candy bars, which he hid under some mag azines and enjoyed when the nurses wer out of sight. My euphoria was short-lived On my second day in the ward the serum sickness began.

It started with wall-to-wall red welts— hives—on my chest. The reaction soo

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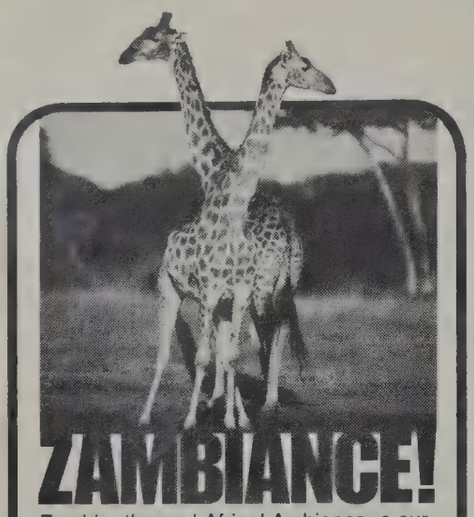

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spread over my shoulders and down my back, cropped up on my thighs and buttocks and then on my face and scalp, all within a few hours. Everything burned; everything itched. The nurses had to wait for orders from a doctor, of course, before they could do anything, and although I'm sure they knew what was happening to me, they weren't willing to tell me. I assumed that I had suddenly developed an allergy to one of the drugs they were giving me—penicillin, Demerol, or codeine. More than four days had passed since the horse serum was pumped in, so that couldn't have been the cause. By good fortune, the physician on rounds the next morning was Dr. Falcon, an immunologist, who was delighted to explain my condition to the four medical students touring the wards with him. When he learned that I was a biologist, he included me in his Socratic teaching session, fortunately asking me questions commensurate with my amateur status as an immunologist: "Now, Dr. Colwell, what happens when a foreign protein enters the body?" "Antibodies." "Señorita Gomez, how many days until the antibody titer equals the concentration of antigens?" "Four to six."

So the cause of the welts was the horse serum after all, and my gigantic case of hives was a perfectly normal reaction to having 90 cc of some other species' serum protein added to my own xenophobic system. Serum sickness, though, is not an allergic reaction, in the proper sense. The hives appear when human antibodies reach a concentration about equal to horse antigen. Each antibody molecule couples with an antigen molecule. These complexes are unfortunately not soluble in the blood, so they are deposited in capillary beds throughout the body, where they cause hives and, in more severe cases, produce other more dire, internal reactions (such as kidney failure). The antibodies, however, continue to form and link up with existing complexes, which go back into solution in the blood when there are two antigen molecules attached to each antibody molecule.

All this I learned in my ward bed from Falcon, the friendly immunologist. He also reassured me that everything I had experienced was normal for a properly, promptly treated viper bite, and that I was lucky there was not more tissue damage. He told me that, in Costa Rica, there are some five hundred bites from poisonous snakes each year—about one for every 4,500 people. Three-quarters of these bites are caused by the fer-de-lance. Before the development of specific antivenins, the death rate was high. Nowadays, virtually all victims receive medical treatment, and only 3 percent die, although a larger percentage suffer some permanent disability.

Fortunately, Falcon's knowledge of immunology had a practical side. He ordered generous doses of cortisone and antihistamine added to my i.v. cocktail—the cure for the cure for the snakebite. The hives slowly subsided, and the cortisone dose was decreased daily for the following ten days. (If a high dosage is withdrawn abruptly, the endocrine system goes haywire.) It became clear that there would be no severe damage to my arm and no surgery was needed to make it functional again. Nine days after I had entered the hospital, I felt well enough to talk my way out, on the condition that I take it easy and use the medications according to a complicated ritual.

My arm was still quite unusable, very stiff from a large internal clot in the area of the bite, where a good proportion of my original platelets and clotting factors lay entombed. The area of the clot, perhaps six inches long and four wide, was very hot for about six weeks, as my white blood cells digested the clot. Eventually, my arm was essentially as good as new. When I left the hospital, I spent a fine day in the countryside with my wife, breathing real air and taking stock of life. She had to leave for California the next day to return to our five-year-old daughter, but I stayed in Costa Rica to pursue some field research I had planned with a group of my graduate students from Berkeley, who were scheduled to arrive in a few days. I was to go through a period in which every step in the rain forest took courage, but gradually my fears lessened.

On my third day out of the hospital, the course I had been teaching ended, and all my colleagues and students arrived together in San José. I was waiting for them with my arm in a sling, but alive and well. They greeted me with great intensity, partly due to relief that the pessimistic predictions that had reached them in the field had not come to pass and partly, I believe, from pride in a job well done—each of them had contributed to saving my life after the fer-de-lance bite. But something else was also involved. What happened to me could just as well have happened to any one of them, and they sensed that from the start. Their joy was for their own lives as well as mine. That night we all went dancing. I didn't dance much, but I can't remember when I've enjoyed it more.

Robert K. Colwell is a professor of zoology at the University of California at Berkeley.

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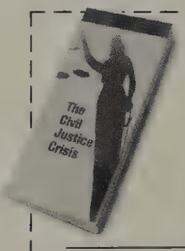

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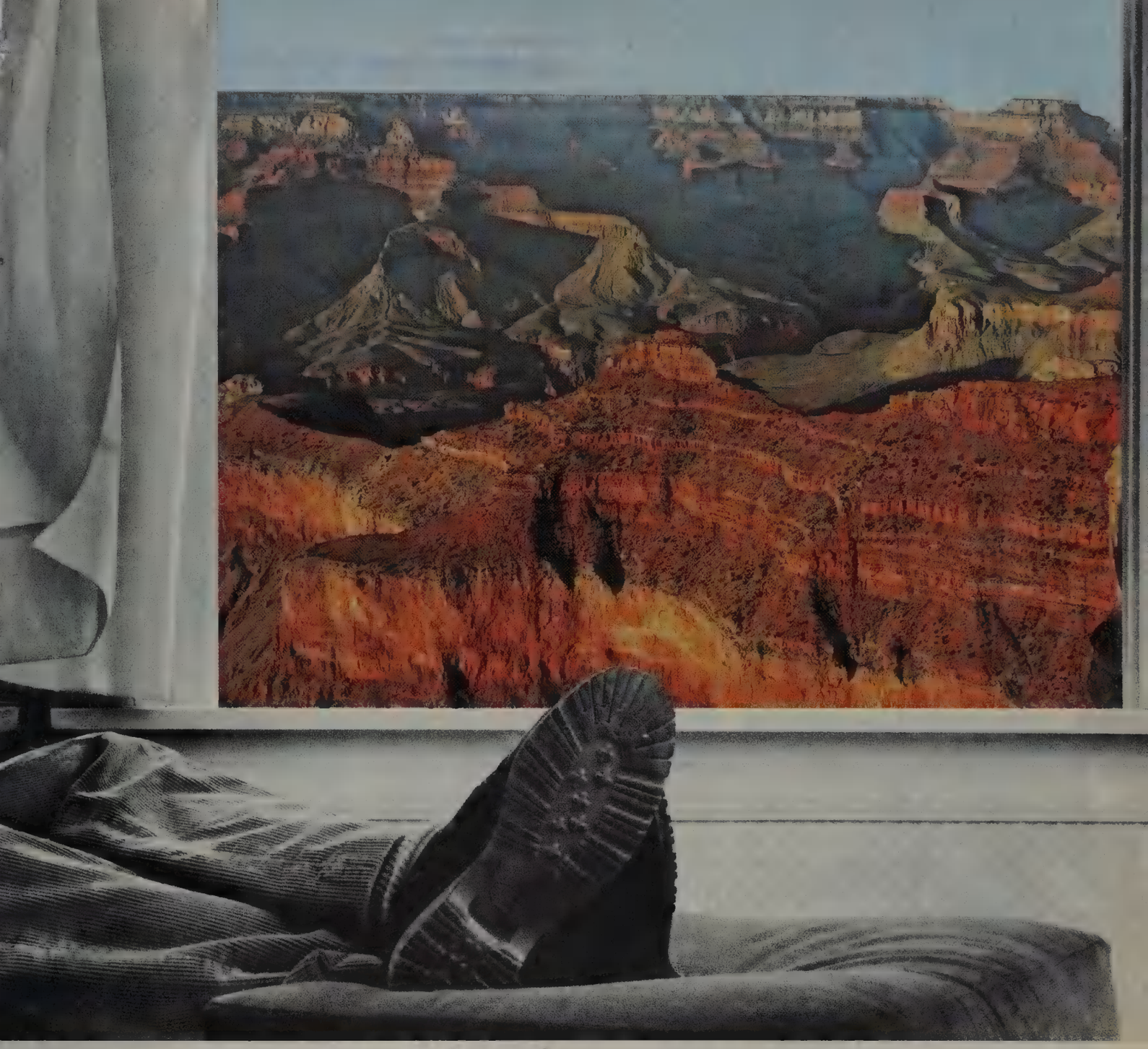

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A Clock of Evolution

We finally have a method for sorting out homologies from "subtle as subtle can be" analogies

by Stephen Jay Gould

Metaphorical and biological meaning do not always overlap. Swans stand for silence, grace, and beauty; geese for honking stupidity. But the small biological space between these birds conflicts with their metaphorical distance. Matthew Arnold spoke for biology in his famous couplet from a poem appropriately titled "The Last Word."

> Let the long contention cease!
> Geese are swans, and swans are geese.

Geese, swans, and ducks belong to the order Anseriformes (Andersen's swan child—the ugly duckling—was reared, albeit unkindly, by a very close relative). Arnold's quip identifies the obvious members of this order, but what other birds reside with them in our classification?

The Anseriformes represent one alternative in an ancient and classic taxonomic debate that stretches back to Greek science and has only recently been resolved: Are flamingos geese (Anseriformes) or storks (Ciconiiformes)?

To a first approximation, a flamingo looks like a goose mounted on the long legs of a stork (see last month's column). When we pass beyond superficial appearances to details of anatomy and behavior, the problem only intensifies—impressive lists of subtle features seem to ally flamingos about equally with each contending group. Basic anatomy might grant a small edge to storks—based on features of the skull and pelvis, and even on details of intestinal convolutions. External form and behavior might give a little nod to geese—webbed feet, a honking voice, and above all, the serrated bill that permits a goose to chop vegetation but, in copiously exaggerated form, builds the complex filters of the flamingo's inverted jaws.

Such a knotty problem leads taxonomists to a search for more exotic criteria. Thus, debate also raged about the mallophagan (feather lice) parasites of flamingos and their possible role in sorting out the relationships of their hosts. Since these parasites are so highly specialized and poorly mobile, they tend to stay put and evolve in sync with their hosts. Since flamingos harbor three mallophagan genera found otherwise only on ducks, some systematists regarded this surrogate evidence as proof that flamingos are long-legged anseriforms. Others replied that the parasites of ducks and flamingos are too similar for such an interpretation—too much of a potential good thing. Even if ducks are the closest living relatives of flamingos, they argued, everyone admits an ancient evolutionary separation between the two groups. As a simpler hypothesis that would dethrone the Mallophaga as evolutionary yardsticks, perhaps flamingos simply received their infestation by "lateral transfer" from passing ducks sharing their waters—so that the similarity only records shared ecology, not evolutionary ancestry.

How do systematists resolve such thorny debates when each side can cite so many similarities in its support? The basic principle is easy enough (though devilishly tricky in application—hence the frustrating tenacity of debates about the classification of such "difficult" groups as flamingos). Biological similarity, defined as simple "looking alike," includes two entirely different reasons for being. Two organisms may look alike because both inherited a set of similar features from a common ancestor. Similarities based upon descent are called homologies. (We share hair, live birth, and a warmblooded physiology with chimps and mice by evolutionary history, or homology.) But features of two organisms may also look alike because both creatures evolved them independently in response to life in similar environments. Similarities based upon independent evolution are called analogies. (Birds and bats fly, and fish and whales swim, by analogy only. Bats and whales remain mammals by descent.)

Since we want our classifications to record genealogy, the basic principle of taxonomy is simple: Divide similarities into homologies and analogies, rigorously exclude the analogies as deceptive, and reconstruct evolutionary trees from homologies alone. So easy to say, but so hard to do. Bats present no problem; they are little more than flying "mice"—that is, mammals point for point, with one odd adaptation clearly geared to current function. But what can we do with creatures squarely between two groups in general appearance, and so replete with complex analogies that descent and immediate adaptation seem hopelessly confused in an inextricable jumble of characters?

Flamingos occupy this middle ground. No one has ever come close to a convincing separation of their homologies and analogies with geese and storks, the two leading contenders for their affinity. How can we tell whether they are basically geese grown long-legged in the shallow-water environments of wading birds or basically storks grown gooselike by independent evolution of bill ridges in feeding? In 1969, Yale ornithologist Charles Sibley wrote a long article on the relationships of flamingos (with K.W. Corbin and J.H. Haavie, in *The Condor*, vol. 71, pp. 155–79). He included a two-page chart covering a century of varying solutions. Most experts took the usual course in troubled waters: They kept all options open and hedged by creating a separate group for

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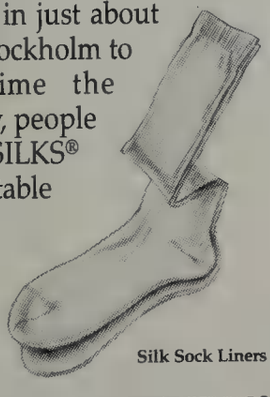

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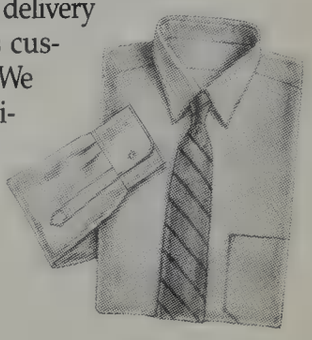

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flamingos midway between geese and storks. A well-known cousin of Matthew Arnold's—Thomas Henry Huxley—headed Sibley's list. In 1867, Huxley opted for what Jules Feiffer once called the radical middle by placing flamingos in the Phoenicopteriformes, right after ducks and just before storks in his general classification.

But this taxonomic muddle has a happy ending. The problem has been resolved. In fact, Charles Sibley and his colleague Jon Ahlquist have nearly completed an evolutionary tree for all birds—the first group ever exhaustively treated by a method that can properly sort homology from analogy. Flamingos, by the way, are storks. (And I'm damned disappointed. My Audubon invert from last month works equally well whether flamingos are truly swans or merely convergent upon them. Still, I somehow developed the gut feeling that geese would win—so, by the way, did Sibley, when he began his work.) Sibley even feels that he can provide a date—forty-eight million years give or take only a bit—for the divergence of flamingos from their so-called sister group (including all descendants of the first group that branches off from flamingos as we trace the flamingo line toward the common trunk of all birds). The sister group of flamingos includes ibises, shoebills, pelicans, storks, and New World vultures—the solution, by sorting analogy from homology, to another old problem by recognizing that New World vultures are storks by homology and carrion-feeding birds of prey only by analogy.

Sibley and Ahlquist have built the evolutionary tree, or phylogeny, of birds by using a molecular technique called DNA-DNA hybridization—a method that can sort homology from analogy. (Molecular phylogeny has been with us for some thirty years, using an astonishing variety of techniques and concepts with varying degrees of success. I choose Sibley's work to illustrate the profession both because I judge his method conceptually superior to all others, for simple reasons explained later, and because Sibley, in his own persistent and hyperenergetic way, has, for the first time, built the complete tree for a major group—and not merely chosen a few uncontested creatures as a pilot demonstration.)

DNA-DNA hybridization is beautifully simple in concept (but quite difficult in detail and application—a fascinating story in its own right, but one that will have to wait for another time if you want to read anything else in this issue of the magazine). DNA, as everyone knows by now, is a double helix made of two strands, each twisted around the other. Most people also know that DNA contains multiple copies (hundreds of thousands in some cases) of many genes (segments of DNA), not just a single copy of each. Sibley's method takes one copy of as many genes as possible and then makes a kind of "brute force" comparison between two species by matching all the DNA that includes a single example of each gene (so-called single-copy DNA). (Since genes may evolve at different rates, we must exclude multiple-copy DNA. Suppose that a species' DNA contains 100,000 copies of a rapidly evolving gene. These repeated sequences will swamp several thousand single-copy genes evolving at average rates and will overestimate the phylogenetic difference between two species. Since we don't know which genes evolve rapidly, slowly, or at average rates, our best estimate will use the brute force method of securing one copy for each gene and trusting—and testing—that positive and negative deviations from average rates will balance in the total wash.)

Sibley and Ahlquist therefore separate out the single-copy DNA and discard the multiple copies. They then dissociate the two strands of the double helix (both steps are easy to say and hard to do). They now have single-stranded DNA containing one copy of each gene. They take the single strands of two species and mix them together. In DNA, as in so much of life, like has an affinity for like. The corresponding parts of the two strands therefore join as best they can, forming a double helix (a so-called heteroduplex) with one strand from the first species and the second strand from another species. The technique then hinges upon a simple chemical fact: The closer the similarity of the DNA from the two species, the tighter the two strands of the heteroduplex will bind, and the greater the energy needed to dissociate them. Binding will be tightest of all for the homoduplex—when both strands come from the same species—and progressively weaker as the DNA strands become more dissimilar. The weaker the binding, the lower the temperature for dissociation. Evolutionary affinity is a simple linear function of heat needed to separate the strands—the lower the temperature, the more distant the relationship.

Why does this method give us an accurate evolutionary tree of branching relationships, and why have the classical data of morphology, physiology, and behavior often failed in detail? Many people suppose, quite incorrectly, that molecular phylogenies work because genes are more real, more basic, more fundamental than the form and behavior of whole animals. We must, in general, struggle against this bad intellectual habit of reductionism and its assumption that proper explanations can only emerge from breaking things into their smallest constituent parts; wholes have as much reality and importance as their building blocks. But we needn't wax so abstract in this case—for DNA wins as a criterion of phylogeny for a specific reason divorced from its status as a molecular code, and not on general principles.

The decoding of phylogeny requires no more than a method for recognizing homology and eliminating analogy. Biologists have long realized that complexity offers the best guide to homology. When similarities between two species are sufficiently widespread and intricate—that is, composed of many hundred utterly unrelated, complex parts—they cannot arise by independent evolution; they must record the passive inheritance of shared descent. Analogous similarity produces uncanny likeness—just consider the marsupial moles, dogs, and mice of Australia—but its results can extend only so far. Natural selection may converge from different directions upon the mechnical optima of certain life styles (thus producing a striking outward similarity in swimming machines, whether they be fish, squid, or mammal), but it cannot undo the homologous handiwork of ages and so restructure an organism that its ties to history are forever lost in current adaptations. If we can look at enough independent details, we will always find homology intact.

Morphology may be our first (and usually adequate) guide, but it just doesn't provide enough independent detail for sorting homology from analogy in difficult cases. Morphology looks complex and multifaceted, but parts do not always maintain their apparent independence. Growth and development link the features of organisms into complex webs of correlation; small changes may trigger cascading effects throughout the body. Similarities that look too complex for analogy may actually arise as consequences of single changes in these triggers. Morphology also acts as the primary breeding ground of analogy, as natural selection guides different lineages to the same optima for similar roles in common environments.

DNA differs from morphology in just those properties that capture homology. DNA is complex enough to preclude analogy as a cause of overall similarity. The items (genes) of a DNA code are also sufficiently independent to guarantee that no simple trigger can engender a large set of apparently intricate similarities. Each gene contains hundreds of nucleotides, each capable of separate change in evolu-

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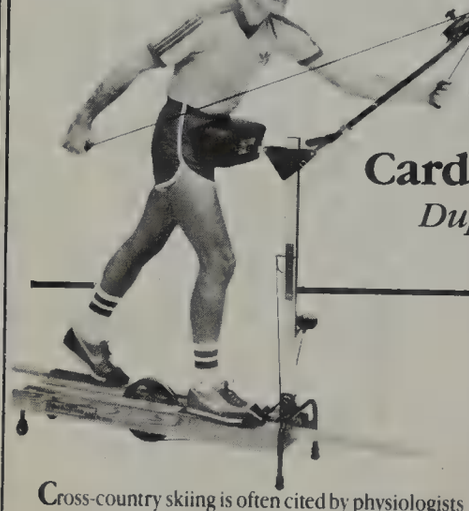

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tion. Such a long string of independen items cannot evolve detailed similarit from initial disparity. A high percentag of item-by-item match in the DNA of tw species must represent homology an shared descent. Sibley and Ahlquist' method of DNA-DNA hybridizatio measures just this matching and uses th largest possible sample size—all single copy DNA. A morphologist may conside hundreds of correlated items. Sibley mea sures millions of independent bits. Thus Sibley's method works for two reasons o mathematical probability, not by any gen eral superiority of DNA over morphology his matches are too complex to evolve in dependently, and his sample size (al nucleotides of all single-copy DNA) is so staggeringly large that any superficia analogy must be swamped by similarity o shared descent.

Such a brute force method possesses a kind of ironic elegance that may even permit us to date the events of phylogeny, not merely to state their relative sequence. In one sense, no technique of molecular phylogeny could be more crude than Sibley's—he simply dumps all the single-copy DNA of two species into his black box and then heats it up. His result, in each case, is just a number—the temperature of dissociation for strands of the heteroduplex. But we live in an age of great sophistication. We could in principle, although it would take forever and cost the world, state the actual basis, nucleotide by nucleotide, of all differences for any number of genes in two species. Why not work with these direct molecular details; why, instead, should we use such a simple surrogate measure—the temperature of dissociation?

To place time on the branches of an evolutionary tree, we need a clock—some measure of evolutionary change that ticks at a constant rate (or at a variable rate that we can calibrate). Genes evolve at different rates. But a measure of change in all genes at once might provide a kind of global average relatively invariant from group to group. Sibley claims that the clock for entire genomes beats with impressive constancy. If a few branching points can then be dated with independent evidence from fossils and geographic distribution, the clock can be set. If the clock beats regularly, all other branching points on the tree obtain a definite date. The determination of forty-eight million years for separation of flamingos and storks relies upon this calibration, not on direct evidence of fossils.

I am convinced that Sibley and Ahlquist have correctly set the relative sequence of branching on the evolutionary

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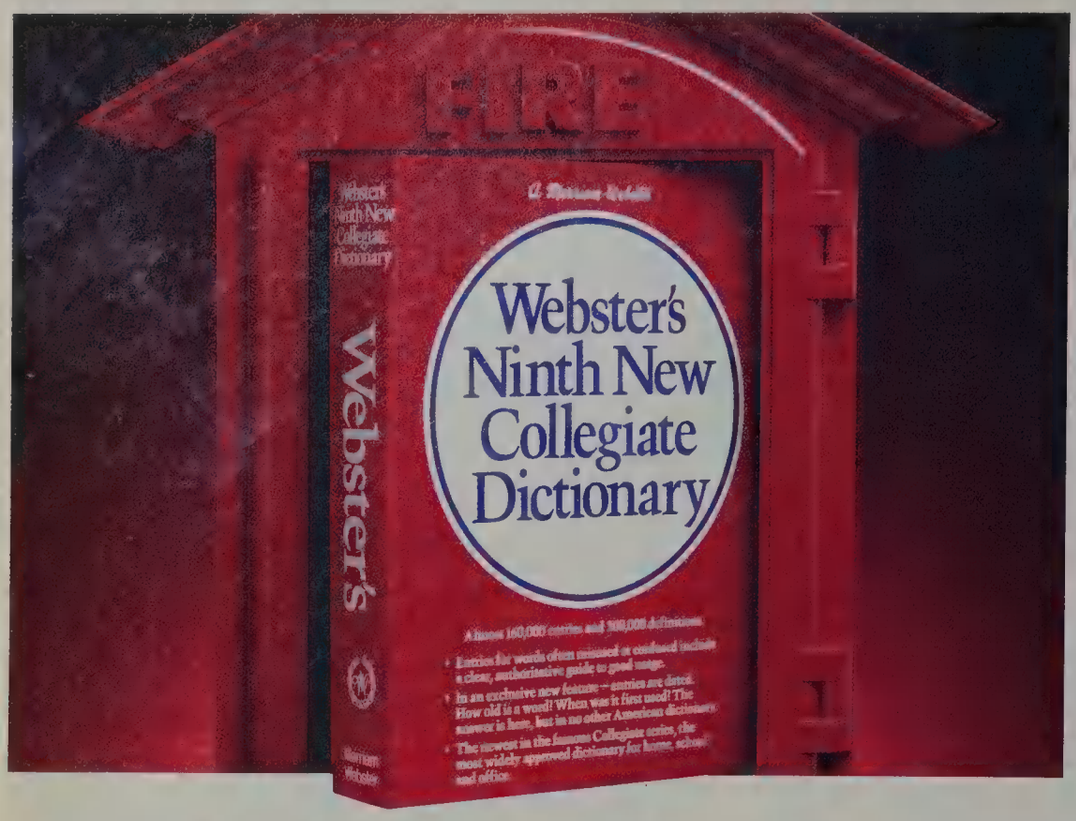

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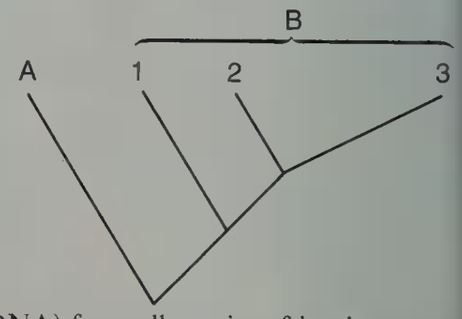
tree of birds—the essence of phylogeny. I am more skeptical about their claims for clocklike precision (neither convinced nor in any way opposed; just waiting for more data from other groups of organisms). In any case, Sibley's claim for "uniform average rate" of evolution in single-copy DNA can be tested in a straightforward way. The hypothesis of uniformity predicts that any species (A in my diagram) will be equally distant (as measured by



DNA) from all species of its sister group (B) because A shares the same branching point with all species of B. Opponents of constancy predict that since some species in B diverged faster and farther than others from the common ancestral state (morphology certainly records these different degrees of departure), A will be closer to some species in B than to others as measured by DNA. (Call A an orangutan, B_1 a gorilla, B_2 a chimp, and B_3 a human, and you will see the point. By Sibley's clock, orangs should be equally distant from gorillas, chimps, and humans; opponents might expect a greater distance between humans and orangs.) Limited testing so far must give the advantage to Sibley. I hope that he is correct.

We should all rejoice in the success of molecular phylogeny because its techniques have probably solved *the* biological problem of the ages, so recognized ever since Aristotle (and surely, in unrecorded form, well before—whenever people puzzled about their place in nature): namely, how, and why, are organisms interrelated? And how do we, so topheavy and physically defenseless, fit into the general scheme? Monkeys fascinate us because we perceive affinity in our guts; carrots evoke no sympathy, even from the kindest of vegetarians, because they don't look and work enough like us.

No other issue has so consumed the attention of naturalists throughout human history and across cultures. Darwin solved the "first-order" problem by showing that a simple history of physical descent, not the inherent and timeless plans of a creator, had forged the pattern of relationships among organisms. Darwin answered the *why*, but not the *how*. He taught us the reasons for similarity; he did not (and could not) specify the actual map of rela-

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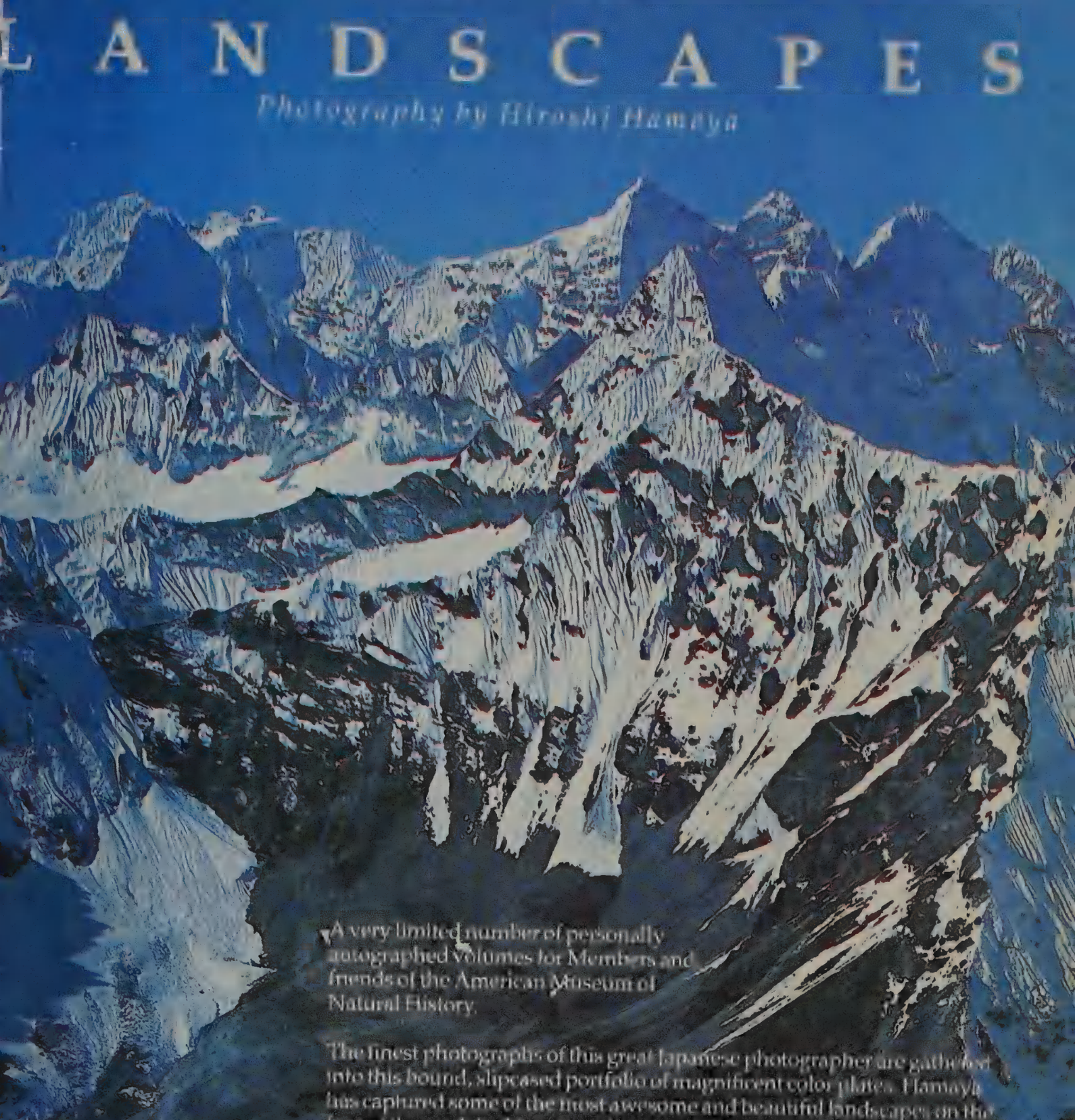

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tionships—the problem of phylogeny. T classical data of morphology provided outline for such a map (and had done long before Darwin), but could not sup all the details because (for reasons pr ously discussed) morphology sometim includes such an inextricable hodgepo of homology and analogy.

If molecular phylogeny has been p sued for nearly thirty years, why do I p claim its success now? Previous stud have usually taken a few widely scatte forms—*the* goat, *the* dog, *the* monk and other maddening and meaningless stractions of biological richness—a drawn a phylogeny affirming what eve one already knows. But natural histori dwell with God in the details. We want allocate our problematical groups (l flamingos), not simply stroke our e with molecular affirmations that mous to rat as sheep is to goat. We want a co plete phylogeny for groups that pique interest, not a simple ordering for a f unambiguous branch tips.

Birds are among the best known and haustively compiled of all biologi groups. Their roster of 9,021 species probably not increase greatly. But wh we know the species of birds, our attem to hook them all up into a comprehens phylogeny have been consistently fr trated by more than the usual number "flamingos"—difficult groups that c flate homology and analogy beyond point of morphological resolution. Sib and Ahlquist have worked for more tha decade to produce the first exhaustive m lecular phylogeny for all families in a m jor group. They have now run 1,600 s cies and managed to place all but 3 of 171 families of birds on their chart.

Sibley and Ahlquist's phylogeny is only complete but also interesting. achieves that lovely optimal level of sci tific originality—conservative enough win our allegiance but replete with s prises to spark our fascination. Again a again, it makes sense (in satisfying, of unorthodox, ways) of situations that m phology had muddled or made distre ingly complex. Consider two exampl one a pleasing affirmation of what shou be so (but morphology had questione the other a surprising but beautifully s sible resolution of an old dilemma.

1. *The case of the ratites.* South Hemisphere continents feature la flightless birds called ratites—rheas South America, ostriches in Africa, wis, cassowaries, and emus in the gion of Australia and New Zealan Since all these continents were or united as Gondwanaland, the curre

separation of flightless birds records geological history, and the phylogenetic relationship of all ratites has not been seriously questioned in recent years. But morphology raised a dilemma of detail—a potential discordance of phylogeny and geography. Some (but by no means all) experts working with morphology argued that Australian emus and cassowaries are most closely related to geographically distant ostriches and rheas and not to the neighboring New Zealand moas and kiwis. But Sibley and Ahlquist's DNA phylogeny accords perfectly with geography: cassowaries, emus, and kiwis (the extinct moas provide no DNA) form a closely knit subgroup within the ratites; they join the ostrich-rhea group at substantially greater phyletic distance.

The case of the Australian songbirds. If God favors beetles among insects because he made so many of them (as the old quip goes), then surely he loves songbirds among our feathered friends. Of 9,021 species of birds, 58 percent (or 5,274) belong to the Passeriformes, or songbirds. The Australian region contains a fair chunk of this radiation—more than 700 species of respectable antiquity, excluding recent immigrants.

As everyone knows, Australia's native mammals tell an evolutionary story well tuned to their geographic status. Australia, though once tied to other Gondwana continents, has been a separate island for several tens of millions of years. The native mammals, nearly all marsupials, have evolved entirely on their own, radiating into roles and niches filled by placental mammals on other continents. Some, like the koala and kangaroo, have discovered morphologies unknown elsewhere. Others have evolved some of nature's most stunning and complex analogies by converging on the common forms of Northern Hemisphere placentals—Australia, for example, sports its marsupial versions of "mouse," "mole," and "dog." But morphology, in this case, does not fail us. All the intricate analogs have retained their basic marsupial signature—the pouch, the epipubic bones, and a host of other features that identify their homologies.

But the songbirds, as traditionally interpreted, tell a different story that makes less sense (geographically speaking) and that requires special pleading to harmonize with Australia's geological history. The Australian passerines include several groups so similar to well-known birds of other continents that classifications have

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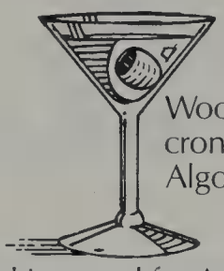

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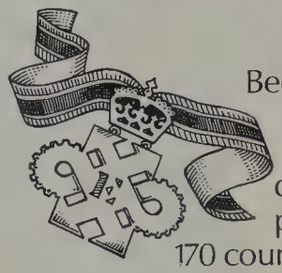

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generally allocated the Australian species to the broad taxa of their look-alikes living elsewhere. The Australian fairy wrens (Maluridae) and Australian warblers (Acanthizidae) have been allied with true warblers (the Afro-Eurasian Sylviidae) in traditional classifications. *Drymodes*, the Australian scrub robin, looks like an Old World thrush, down to details of bone lengths and bill proportions. *Daphoenositta* looks and lives like a nuthatch; its taxonomic position has remained something of a mystery but, if only *faute de mieux*, ornithologists generally place it adjacent to the true nuthatches in their classifications. The monarch flycatchers of Australia generally occupy a taxonomic position next to the true flycatchers of other continents, and one genus of Australian robins (*Microeca*) looks so much like an Old World flycatcher that Ernst Mayr, our greatest living ornithologist, once considered (as he confessed to me) placing them in the same genus as European forms.

If these taxonomic placements are correct (by recording homology), then we are forced into an improbable zoogeographic hypothesis. Warblers, thrushes, flycatchers, and nuthatches are distinct groups, long separate. If Australia really harbors a few representatives of each, then they must have arrived in several separate waves of colonization—and such a theory of multiple invasion has been the traditional (and uncomfortable) view. But why should mammals and birds tell such different stories? Why should Australia's mammals form a coherent group with remarkable convergences upon foreign placentals, and its birds be an unrelated hodgepodge of so many separate invasions? Yes, I know—birds fly and mammals don't. Still, most birds are not as mobile as their metaphorical status implies—and Australia has resided thousands of miles from anywhere else for a long time.

Sibley has just completed his DNA phylogeny for the oscine passerines (or true songbirds), including all these Australian forms—and, as he told me on the phone last week, he received the greatest surprise of his decade's labor. By DNA homologies, the oscines break into two major groups, separated by fifty-eight to sixty million years: the Muscicapae, including thrushes, swallows, starlings, warblers, larks, sparrows, and finches; and the Corvi, including most prominent songbirds of the Australian region (lyrebirds, bowerbirds, fantails, drongos, birds-of-paradise) and also crows, ravens, magpies, jays, orioles, shrikes, and vireos. The geographic concordances are simple, elegant, and convincing. The Corvi diversified in the Australian region, the Muscicapae elsewhere. (This discovery, by the way, will bring much joy to patriotic friends down under, for it forces a reinterpretation of Australia as active supplier, not only as passive recipient of superior forms evolved elsewhere [as the wipeout of so many marsupials by introduced placentals has encouraged]. The crow subgroup "escaped" from Australia to Asia, probably some twenty to thirty million years ago, and evolved there to its current diversity. But Australia, as Sibley writes, "was the nursery of the Corvi.")

Sibley's phylogeny beautifully resolves, in one swoop, all the old dilemmas listed above. The Australian "wrens," "warblers," "robins," "nuthatches," and "flycatchers" had been placed with their look-alikes in the Muscicapae—the great non-Australian branch of the songbirds. Every last one of these troubling species belongs, by DNA homologies, in the Corvi—the other great branch that evolved in Australia. We need no special pleading, no multiple migrations from impossible distances. The morphological similarities to members of the Muscicapae are analogies, not homologies.

The Australian songbirds, in other words, tell the same tale as the marsupi-

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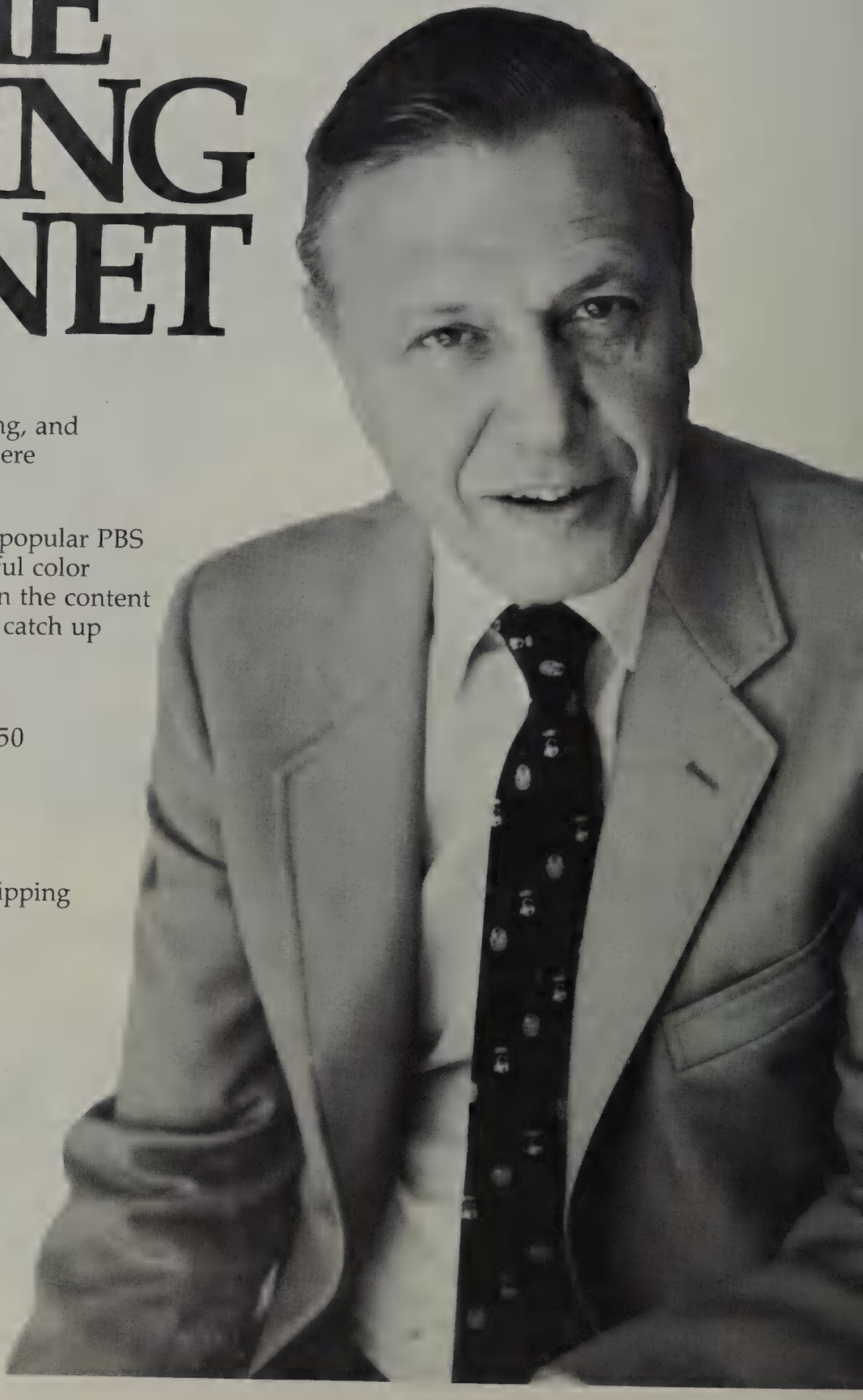

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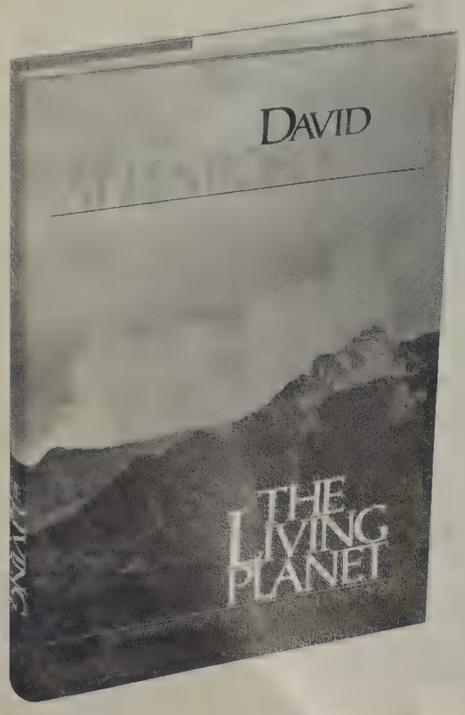

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–phylogenetic coherence in geo-
ohic isolation with rampant conver-
ce upon groups that inhabit the rest of
world. Marsupials retained morpho-
cal signatures of their homologies; the
stralian passerines either failed to sign
vrote in an ink as yet invisible. If it can
erate such sensible conclusions, Sibley
Ahlquist's method must be right (this
gut feeling, not a logical argument).
Lord may be subtle, to recycle an Ein-
n quote of two columns ago, but he is
perverse.

We should all care deeply about
ley's conclusions, for his sensible reas-
ments by homology reinforce the most
portant theme that evolutionary theory
taught us—the overwhelming pre-
ninance of history as the cause of na-
e's ordering. Convergence (or similar-
by analogy) can be, in Sibley's words to
, "subtle as subtle can be," yet analogy
not overwhelm the likenesses im-
nted by history and descent into the
gest taxonomic sample of all—the sin-
-copy DNA of any species. But history
ws along constrained pathways of form.
e optimal solutions for form in certain
vironments act, one might almost say,
a set of timeless Platonic types. Wren-
ss, dogness, and wormness are formal
mes that transcend time, and nature's
otoplasm flows through them again and
ain. Life becomes a fascinating and
mplex interplay of these opposing con-
otions: the homology of history and the
alogy of optimal form; dynamism and
ucture; motion and inherence; unique-
ss and repetition.

Sibley's work, and other efforts of mo-
ular phylogeny, have received a fair
g of press lately, but I do not fully un-
rstand why we are not proclaiming the
ssage from the housetops. Biology and
mmon culture have struggled to portray
e relationships of organisms for thou-
nds of years. We finally have a method
at can sort homology from analogy. The
swer oozed up on us over many years; it
so emerged from a profession with low
blic recognition and no designated No-
l Prize, so most outsiders to the club
ven't noticed. Perhaps we should mount
e parapets and shout: "The problem of
ylogeny has been solved." But then we
ust descend and get to work—for the so-
tion is only a beginning, a calibration
d context for all the interesting ques-
ons. For starters, would you believe (as
bley now claims) that chimps are closer
humans than to gorillas?

*Stephen Jay Gould teaches biology, geol-
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The Prince and the Painter

by Stephen J. Pyne

KARL BODMER'S AMERICA, Introduction by William H. Goetzmann, Annotations by David C. Hunt and Marsha V. Gallagher, Artist's Biography by William J. Orr. *Joslyn Art Museum and the University of Nebraska Press, $65.00; 376 pp., illus.*

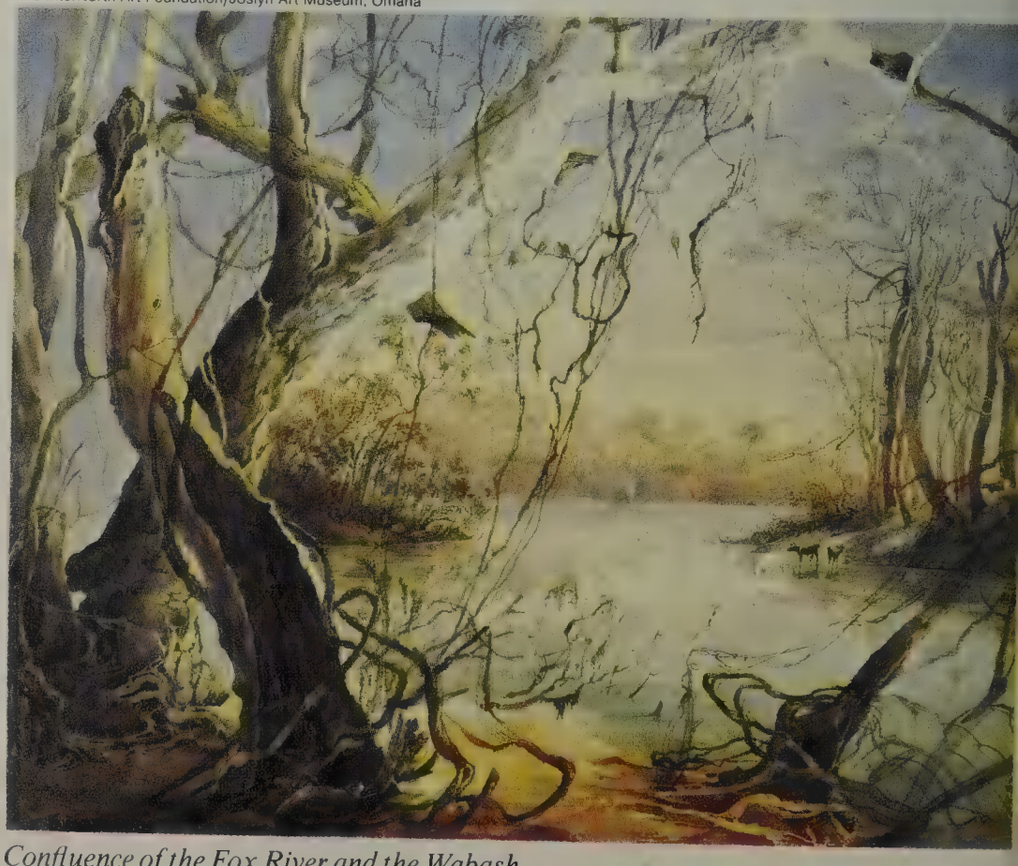
In frontier days, appreciation for the American Indian increased with distance. On the frontier itself, the Indian was considered a nuisance. Farther east, especially in centers of learning and natural history, he was sometimes an intellectual puzzle. In Europe, he became an ethnographic marvel. America's West was also Europe's, and the important images and information about the West were as much a product of European high culture as of the experience of frontiersmen.

Thus in the 1830s, when artists went West to paint the Indian, two were Americans from the East (George Catlin, Alfred Miller), and two of the three major expeditions had European sponsors—William Drummond Stewart, an adventurous Scottish baronet, and Prince Maximilian of Wied-Neuwied, a German devotee of natural history. Maximilian's expedition had the strongest intellectual component, yet its most stunning legacy was the meticulous portfolio of its young Swiss artist, Karl Bodmer. The purpose of Catlin's photographs was to record, and they were often hastily done and suggestive rather than definitive; Miller's watercolors, in contrast, were lyrical rather than documentary, evoking a preadamic state of nature. But Bodmer's work combined the hard edge of science with a Romantic delight in the wild, the natural, and the picturesque.

That Bodmer painted the Indians of America was something of an accident. Inspired by Alexander von Humboldt, Prince Maximilian had previously traveled to Brazil (1815–16), where he explored jungles and assembled natural history collections. His published account featured his own drawings, and friends tactfully suggested he engage a professional artist for his next journey. Bodmer had just illustrated a travel book on the Moselle Valley; it caught the attention of Heinrich Schinz, a Swiss naturalist, who recommended Bodmer to Maximilian. After some haggling, Maximilian and Bodmer came to terms, and on May 17, 1832, they set sail for America to collect specimens from the West and to study th "aboriginal nations of America."

Bodmer and Maximilian spent a yea dodging cholera epidemics, but visited th major centers of learning for natural hi tory (among which Philadelphia was mos prominent), conversed with American sa vants, and spent nearly five months a New Harmony, Indiana, recuperatin from illness, doing research in the large l brary, and discussing science with th town's prominent naturalists. Bodme made a brief excursion to New Orlean and back. Finally, in the spring of 1833 the party traveled by steamboat and keel

The InterNorth Art Foundation/Joslyn Art Museum, Omaha



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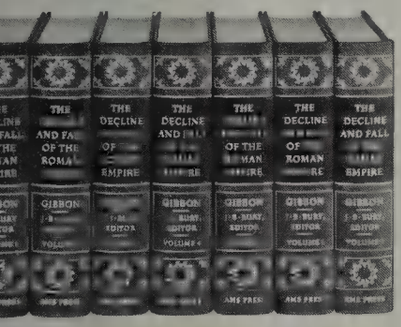

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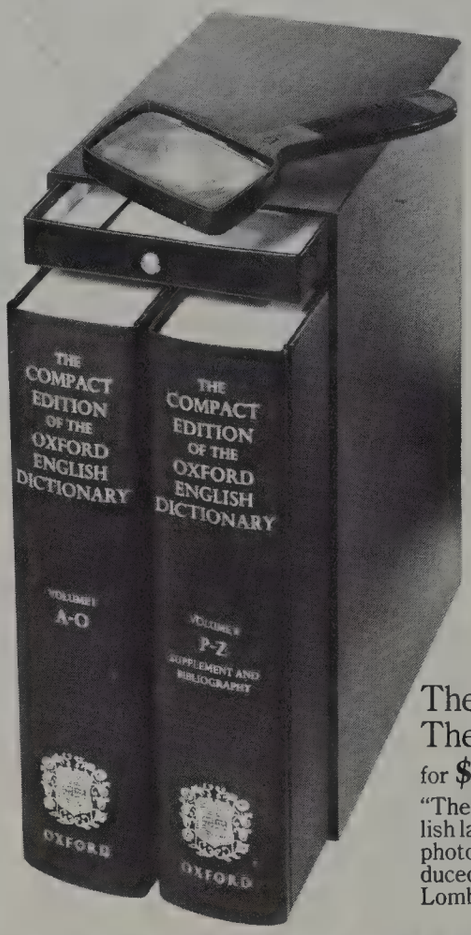
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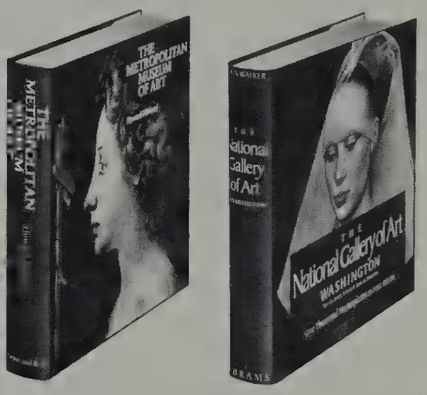

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boat up the Missouri River fur trade route to Fort McKenzie. Bodmer painted landscapes and drew animal specimens collected by Maximilian.

At the fort, however, their ethnographic impulses were satisfied. A rumor that being painted by Bodmer made one immune to bullets brought the artist abundant clients, most decked out in full regalia. Avidly he painted Blackfeet, Kutenai, Atsina, and Assiniboins. The contrast between these magnificent people and the demoralized Indians Bodmer had seen near settlements was powerful. Maximilian pondered the mystery of the Indians' origin, quickly seizing on the idea that they had a common ancestry with the tribes he had known in Brazil. Bodmer declined to paint the fur traders and trappers he encountered; this was an ethnographic expedition, not an exercise in portraiture or an indulgence in the picturesque.

Persuaded not to travel south to the Rockies, the small expedition retired to Fort Clark, North Dakota, to spend five cold, wretched, filthy, undernourished—but productive—months among the Man-

ns. Two years later, smallpox virtuly wiped out the tribe. In July 1834, afr a detour to Niagara Falls, Maximilian, odmer, a hunting companion, their specens, and two live bears left New York r Europe. Tragically, most of Maximiln's collections had been destroyed in the nking of a Missouri steamboat. The most nportant record of their travels, however, as Maximilian's detailed diary and odmer's portfolio. Between 1839 and 843, *Travels in the Interior of North merica* was published in French, Gerian, and English, with a supplemental atas consisting of eighty-one aquatint plates om paintings Bodmer composed out of is field sketches.

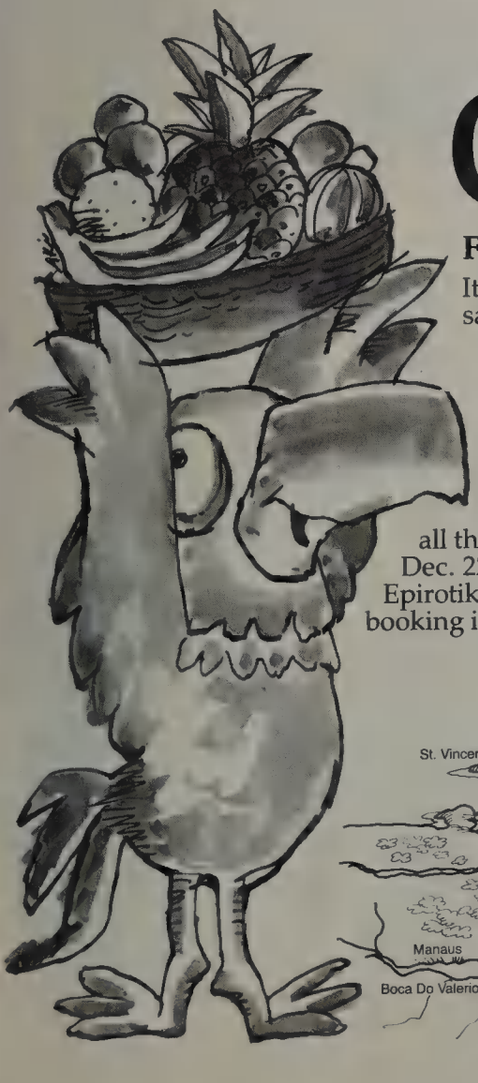
Although the book was a splendid prouction, its expensive price made it a fiancial disaster. Prince Maximilian later lanned, but had to abandon, a journey to entral Asia. Bodmer declined a chance to oin an expedition to Egypt. Exhausted om his labors, he eventually retired to ne artists' colony at Barbizon, France, here he indulged his passion to paint forsts and animals. For a while he achieved ome financial success and critical attenon doing illustrations for periodicals, but n comparison with his North American rt, this work seems insipid and academic. His last years were spent alone—melancholic, sick, out of artistic favor. He and Maximilian continued to correspond.

Bodmer's American travels stood as a unique experience, a magnificent anomaly compared with the work he did before and after it. As an artist he is best known, rightfully, for his wonderful portraits of Indians. Because Bodmer was hired to illustrate a scientific expedition, his art was tempered by that purpose. The resultant sketches and watercolors tend to be uncluttered, unconventional, a bold mixture of hard-edged clarity and delicate detail. The portraits, in particular, stand up both as ethnographic types and as portrayals of individual people. There is nothing sentimental about them. Indeed, the painted faces, animal headdresses, and stoic glares often have a diabolical quality.

The landscapes are more complex and somewhat more conventional. Except for a few scenes on the Missouri where the rock outcrops are reminiscent of Rhine castles, Bodmer's landscapes lack the intensity of his portraits or the calculated frenzy conveyed in his aquatints of Mandan dances or Blackfoot-Assiniboin battles. Perhaps most unsettling are his watercolors of religious sites; Bodmer makes a prairie shrine ringed with buffalo skulls into a Mandan Stonehenge.

Bodmer also painted buffalos, vultures, pronghorns, and sandcranes—all of which have the same qualities that make his Indian portraits so compelling and informative. Apparently it was the synergism of naturalistic realism and Romantic sensibility that gave the portfolio its special quality. Without the science, Bodmer's art lost its power. But for all his extraordinary skill, Bodmer's synthesis was not unique. His pictures are startlingly pure compared with the more traditional academic and museum art of the era, but they are of a piece with a tradition of art in the service of science. Bodmer's portfolio—like Maximilian's expedition—was part of what historian William Goetzmann has termed a Second Great Age of Discovery. They are in the same tradition that inspired the watercolors of William Hodge and the specimen drawings of George Forster—both of whom sailed with Captain Cook in the eighteenth century—and the watercolors of Antarctic penguins and icebergs done by Edward Wilson, the artist-physician with Robert Scott's expedition, in the early twentieth century.

This isn't the first book about Prince Maximilian's travels, and it isn't the only book on Bodmer's art. But it is the only one to include all of Bodmer's American works. The production is well designed and generously executed; the text shim-



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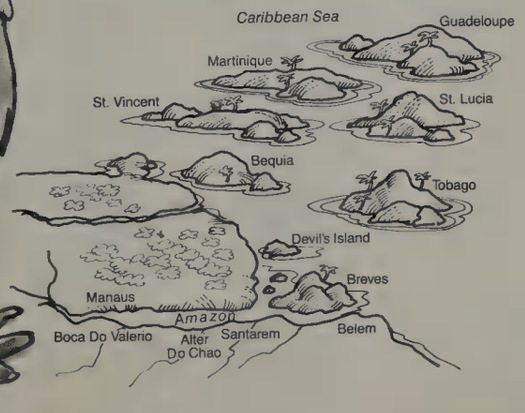

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mers with insight. William Goetzmann's introductory essay deftly describes the intellectual context of the expedition, both in the United States and in Europe—the state of knowledge about the West, its natural history, and the Indians who lived there; and the intense ferment in German thought, especially about problems of life and history, that explains much of Maximilian's curiosity. Maximilian emerges as a serious scholar, and not as a dilettantish tourist or a bored noble eager to shoot wild game. Extracted from Prince Maximilian's letters and diaries, the annotations to the plates—written by David Hunt and Marsha Gallagher—are unobtrusive and informative, complementing rather than confronting the reproductions. A biography of Bodmer by William Orr successfully places the American episode in Bodmer's evolution as an artist. Inevitably, there is a good deal of overlap among these three parts of the book as they describe the critical American journey. But each accents the story differently, and the result is an ensemble, not an anthology.

The book pays tribute to Bodmer not only in its message but in its medium. The mixture of affecting detail and bold concepts, the largeness of the book and the lightness of its composition convey the same impression of rigor and feeling that emanate from Bodmer's best work. *Karl Bodmer's America* will become a valuable sourcebook for scholars interested in the West, Indians, and American intellectual history. The expense of the book will discourage casual buyers, but nothing about it should discourage casual readers. Anyone who wishes to learn what the West was like in the early 1830s and how our images of it have come to be forged will find the book a delightful introduction.

Young Male Bullfrog

The InterNorth Art Foundation/Joslyn Art Museum, Omaha

Stephen J. Pyne is an associate professor of history at the University of Iowa. He has published books on exploration, the history of science, the Grand Canyon, and wildland and rural fire.

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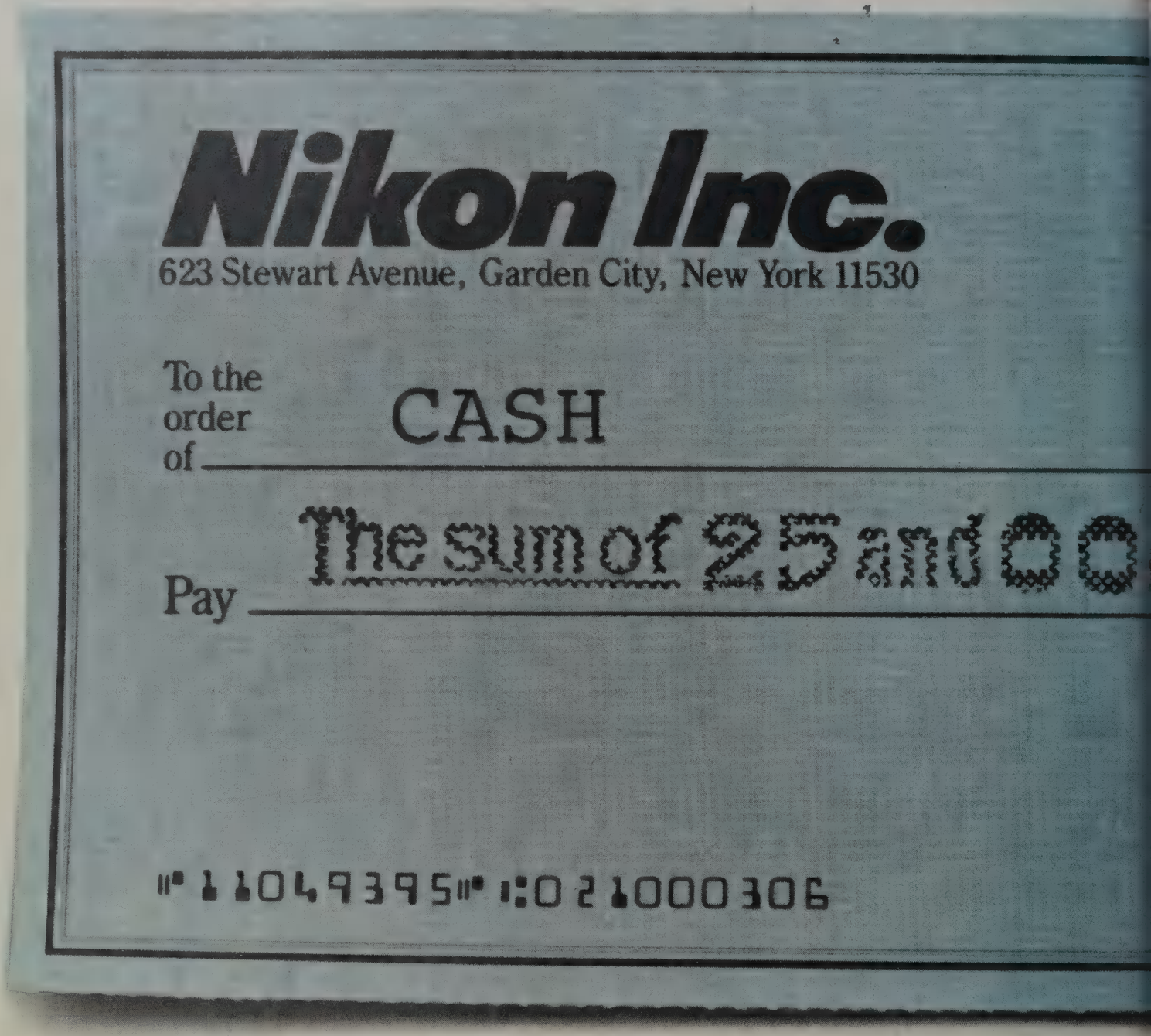

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The Redheaded Newcomer

adicchio, an Italian immigrant,
as achieved a special status in America

Raymond Sokolov

Everyone has had the experience of rning a new word and then coming ross it over and over again immediately erward. But how often does this happen th a new vegetable?

In the late fall of 1978, in Vienna, I first countered a dark red salad "green" with attractively bitter taste. Moving southward into Italy, I kept seeing heads of this red "lettuce" everywhere. Italians called it *radicchio*. Upon returning to New York, I began seeing it in supermarkets, where it sold for a small fortune.

The process by which this distinctively colored and flavored traditional winter green of the Venice region achieved its current status as the very signpost of chic dining in advanced American restaurants is not recorded. But it happened very rapidly, as part of the general hunger for dramatically exotic foods inspired by the *nouvelle cuisine*. A computer search of the *New York Times* shows how quickly radicchio ceased to be a mysterious oddity

Three recipes adapted from *Pasta and Rice, Italian Style* by Efrem Funghi Calingaert and Jacquelyn Days Serwer (Charles Scribner's Sons)

Radicchio alla Griglia

(Grilled Radicchio)

- 2 medium heads radicchio
- ½ cup olive oil
- Salt and freshly ground pepper

1. Preheat broiler.
2. Remove and discard hard outer leaves. Cut each head vertically into 4 pieces, and wash well in cold water. Shake vigorously and pat dry with paper towel.
3. Put pieces on a dish, drizzle with olive oil, and sprinkle with salt and pepper.
4. Place the pieces on a rack and run them under the broiler for 3 to 4 minutes on each side. Grilled radicchio is equally good served cold.

Yield: 4 servings

Risotto with Grilled Radicchio

- 2 heads radicchio, grilled (see recipe above)
- 5–6 cups meat stock
- 6 tablespoons butter
- 1 small onion, minced
- 2 cups Italian arborio rice (or Carolina long-grain rice)
- ⅓ cup Cognac
- ¾ cup freshly grated Parmesan cheese

1. Chop the grilled radicchio crosswise into small pieces.
2. Bring the stock to a boil, then reduce heat so that it simmers gently.
3. Melt 2 tablespoons butter in a heavy-bottomed saucepan over medium heat. When the foam subsides, add the onion and sauté until translucent. Then add the radicchio and sauté for 2 to 3 minutes more.
4. Add the rice, raise the heat to medium-high, and sauté for 1 to 2 minutes longer, stirring vigorously. Add the Cognac, stir, and let evaporate. Then begin adding the broth a cup at a time, over medium heat. Stir well around the sides and bottom until the liquid is absorbed but the rice is not completely dry. Keep adding broth and stirring in this way. The consistency should always be creamy. Depending on the rice, it will take from 18 to 25 minutes to cook. Near the end it is advisable to add the liquid cautiously, since the rice will absorb it more readily when almost done. If you run out of broth, simply add hot water. The risotto is done when it is *al dente*, tender but firm. The sauce should be creamy, not runny. Just before the rice is done, add cheese and remaining butter. Stir well and taste for salt. Turn heat off, cover, and let rest 1 to 2 minutes. Then serve in a heated dish.

Yield: 4 servings

Penne al Radicchio

(Quill-shaped Macaroni with Radicchio)

- 3 tablespoons butter
- 1 medium onion, minced
- 3 tablespoons vegetable oil
- 1 pound radicchio, washed and cut into half-inch pieces
- Salt and freshly ground black pepper
- ½ cup dry white wine
- 8 ripe plum tomatoes, peeled and puréed, or 8 canned Italian tomatoes, puréed
- 1 cup heavy cream
- 1 pound penne (or similar pasta)
- ¾ cup freshly grated Parmesan cheese

1. Heat the butter in a large skillet and sauté the onion until translucent.
2. Add the oil, the radicchio, salt, and pepper. Stir well. Cook for 5 minutes. Add the wine, stir, and cook until evaporated. Add the tomato and 2 cups water. Bring to a boil, reduce heat, and simmer for 45 minutes, stirring from time to time. If the sauce gets too dry, add a little water.
3. Add the cream to the sauce, stir, and simmer for another 10 minutes.
4. Meanwhile, bring 4 to 5 quarts of water to a boil in a large pot. Salt lightly and drop in the penne or other pasta.
5. Start testing the penne for doneness after 8 minutes or so. Drain in a colander when the pasta is *al dente*, still a bit chewy but neither tough nor limp.
6. Toss the sauce and the pasta together in a heated bowl or other serving dish. Add the Parmesan cheese. Toss. Taste for salt. Serve immediately.

Yield: 4 servings

l Solomon; Wheeler Pictures

and turned into just another familiar feature of gastronomic chic.

On April 19, 1981, a reader's query to the garden page asking for a source for radicchio seeds drew a blank from "Garden News." But by May 3, the newspaper of record had recouped. Alert readers had supplied two sources for "the hard-to-find seed of Italian red chicory, radicchio," which was also identified in the same paragraph as "red verone."

This clarification led to more confusion. Red verone was a half-baked version of the French name for radicchio, emanating from the French seed company, J.A. Demonchaux, of Topeka, Kansas, which was one of the two suppliers mentioned in the article. Then there was the business of calling radicchio "chicory."

Perhaps gardeners were not confused by this identification. Well-grounded Linnaeans would have known that the true chicory, *Cichorium intybus*, is what supermarkets and most of the rest of us call endive (also Belgian endive, or witloof). This expensive blanched product is usually produced in Belgium. The white, boat-shaped leaves, called *chicons*, grow on parsniplike roots that are marginally edible but most commonly employed as an admixture to coffee. In the mid-nineteenth century, someone noticed that chicory root left in the dark produces white leaves. The head horticulturist at the Brussels Botanical Gardens, a certain M. Brezier, perfected the new vegetable. The first box was imported to the United States in 1911.

Weed-conscious Americans also know true chicory in a wild form that produces appealing blue flowers alongside roads. We have had these weeds since the last century, but I don't recommend trying to grow Belgian endive from their seed.

You certainly shouldn't try to use their seeds to grow true endive, *Cichorium endivia*, which may belong to the same genus as chicory but is quite different. American markets sell its green leaves as chicory and escarole. The scientific names for these two species of *Cichorium* are confusing in themselves, since *intybus* and *endivia* are actually both reflexes of a Greek word meaning, you guessed it, endive or chicory. And since the art of plant description in ancient days was primitive, it is impossible to tell if the ancestor words for chicory and endive were meant to refer to different plants in a consistent way or were used redundantly.

Today, even with binomial names and a relatively stable horticultural situation, confusion is the word on the *Cichorium* front. Endive is a chicory, chicory is an endive, and radicchio . . . well, according the *New York Times* food advice colum of April 27, 1983, radicchio is a "wi form of chicory most commonly assoc ated with the Veneto region of Italy."

There is some truth in the above, fa more than in the contradictory and incon plete information the newspaper had ea lier printed on radicchio culture. Radi chio is a true chicory (the same species a Belgian endive). But it certainly isn't wil Only careful treatment will encourage th roots to produce those red leaves that hav made the plant an international superst This is not the place nor am I the fellow t advise you specifically about the appropr ate methodology for growing one's ow radicchio in, say, the New York metropo itan area. A great deal seems to depend o climate. But the classic method generall begins with a midsummer planting. Be fore winter, radicchio grows a first crop o mild green leaves suitable for salad. Afte these are cut back, if the roots are kep warm—but not so warm and humid tha they rot—cold weather will promote th appearance of a second crop, this time o red leaves.

The radicchio we tend to see in our mar kets comes in tightly "hearted" heads This is the traditional radicchio variety o Castelfranco, a town in the Veneto regio

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Bali, Indonesia

ere the great Renaissance painter Gior-
ne was born. In nearby Treviso, there is
ifferent variety that does not heart, but
oduces long, straight leaves, somewhat
e Romaine lettuce, with white, celery-
e stalks and ruby red, white-veined
ves.

Sometimes, the two varieties are mixed
make a so-called Treviso salad, but if we
to believe the late food historian
averley Root, the two are never mixed
Treviso. Trevisan radicchio is so prized
Treviso that, before Christmas, it has its
n market in the loggia of the Palazzo
i Trecento. And the plant has its own
k jingle:

Se lo guardi, egli è un sorriso
Se lo mangi è un paradiso
Il radicchio di Treviso.

To look at, it's quite nice
To eat, it's paradise
The radicchio of Treviso.

All in all, this is a good description of an
tremely attractive leaf vegetable. For
e gardener, radicchio will provide a test
skill at controlling a winter environment
mewhere between outdoor reality and
e centrally heated indoors. Treviso obvi-
sly has a milder climate than most
rtheastern winters. The only reliable-
seeming account of radicchio culture out-
side Italy that I have seen is in Joy Lark-
com's *The Salad Garden* (London: Wind-
ward). She is the only writer on the subject
who actually seems to have grown the
plant, and she recommends high polyeth-
ylene tunnels. But I would embark on this
only in an experimental spirit under
American conditions.

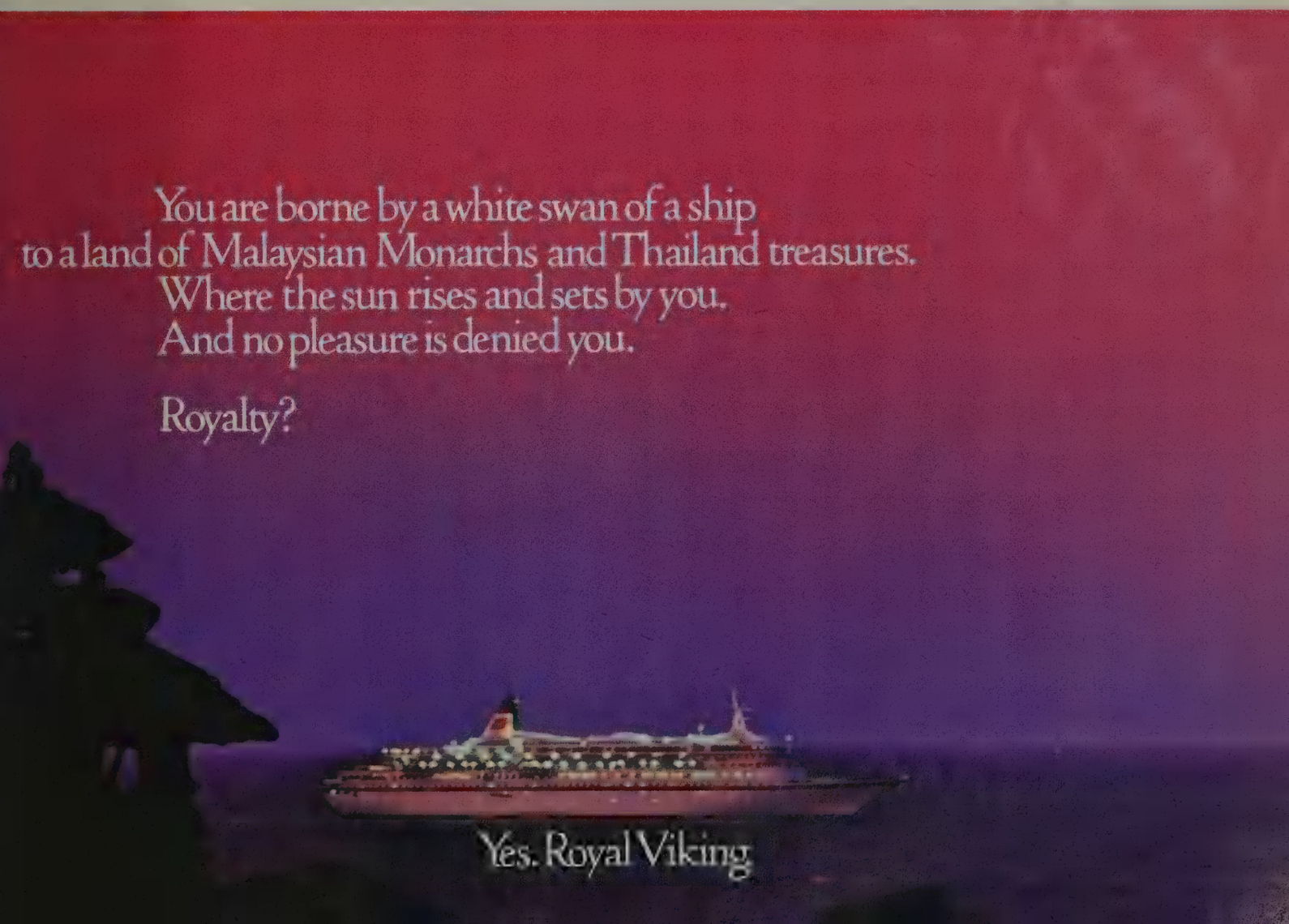
As a cook, however, I feel more confi-
dent about tackling radicchio. First of all,
there's no mistaking it. If you serve it raw,
it adapts well to new companions and goes
into salads of almost any mix. And if you
want to enact a sort of Linnaean pun, you
could serve it with the true endive we call
chicory. Or you could do what the Market
Dining Room in Manhattan's World
Trade Center does and mix it, shredded,
with its species mate, the true chicory we
call endive.

Radicchio can also be cooked. I first ex-
perienced radicchio grilled in olive oil one
New Year's Eve in the early eighties. This
winter, the same elegantly bitter mixture
of radicchio and olive oil flavors showed
up as a garnish for a concoction of salmon
mousse and crayfish at Dupuy Canal
House in High Falls, New York.

This was a relatively restrained use of
radicchio during the high tide of its fame
and glamour. The *Times* data search
turned up dozens of references to radic-
chio extravaganzas in restaurant reviews.
Times critics were not given pause by
such edible gewgaws as a "duck salad con-
sisting of leaf lettuce and radicchio leaves
tossed with slivers of duck in a raspberry-
accented vinaigrette" or the west coast
Mexican *nouvelle cuisine* menu that in-
cluded radicchio and smoked chicken ta-
cos with red chili mayonnaise.

In their hysterical lunging after novelty,
American chefs have overlooked some
very fine, traditional Italian radicchio
dishes. I had never had pasta or risotto
with cooked radicchio until I traveled to
Rome last year. On returning home, I was
fortunate enough to discover recipes for
these splendid dishes (see below) in a
cookbook I had somehow previously over-
looked: *Pasta and Rice, Italian Style*, by
Efrem Funghi Calingaert and Jacquelyn
Days Serwer. The first lady is an Italian
cooking teacher; the other an American
with experience working in Italian restau-
rants. Their recipes reflect what one actu-
ally finds today in Italian restaurants, in-
cluding radicchio in its proper cultural
context.

*Raymond Sokolov is a writer whose spe-
cial interest is the history and preparation
of food.*


You are borne by a white swan of a ship
to a land of Malaysian Monarchs and Thailand treasures.
Where the sun rises and sets by you.
And no pleasure is denied you.
Royalty?
Yes. Royal Viking

Roan Mountain, North Carolina

by Robert H. Mohlenbrock

An early name for the area was Cloudland. From a broad base 2,500 feet above sea level, Roan Mountain rises to 6,285 feet, forming a rounded divide that extends nearly five miles along the North Carolina–Tennessee line. On either side of the divide, rounded spurs alternate with V-shaped valleys. Oak and chestnut forests once covered the lower slopes, but these were cleared many years ago for cultivation and timber (a blight that struck the chestnuts in the late nineteenth century helped to speed the process along). Above 3,500 feet, however, large tracts of natural habitat persist, including catawba rhododendron gardens that offer a spectacular show in June. The rhododendron communities and other treeless areas, referred to as balds, seem inexplicable freaks in an otherwise forested area.

In a band about 3,500 to 5,000 feet above sea level, where the deep, rich soil is relatively free of surface rocks and outcrops, American beeches and sugar maples may stand seventy feet tall. Yellow birch, apparently because it is better adapted to cooler temperatures, becomes common near the upper limits of this forest community, which also has a scattering of shorter trees—sweet birch, Ohio buckeye, mountain and striped maples, and smooth serviceberry. There is a shrub layer composed of hobblebush vibernum, alternate-leaf dogwood, and elderberries; beneath it, a number of wildflowers span the growing season. Jack-in-the-pulpit blooms in early spring, followed by the great star chickweed, with its large, white flowers. Orange jewelweed blooms in summer, and the branched white aster in the autumn.

Upslope, the beeches and sugar maples become smaller and are more widely spaced as they reach their environmental tolerance limits. Above 5,400 feet and all the way to the summit—where the climate is cooler, snow more plentiful in winter, and the winds stronger—they are replaced by a coniferous forest of red spruce and Fraser fir. Scattered among the cone-bearing evergreens, which raise their needle-clothed branches to nearly ninety feet, are such deciduous trees as yellow birch, striped maple, mountain ash, and sweet buckeye. Beneath the canopy trees there is a modest shrub layer, which includes an occasional rhododendron. Aided by thick summer fogs, which hover over the mountain, mosses and lichens cover more than half the ground surface, often edging their way up the tree trunks for four or five feet, and wispy strands of *Usnea* lichens hang from the tree limbs. A few flowering herbs, such as mountain sorrel, foamflower, and purple turtlehead, rupture the moss cover.

The spruce-fir forest occupies Roan Mountain's most rugged terrain, where numerous exposed rock outcrops occur. This stony topography is particularly evident at Roan High Bluff, a scenic overlook reached by trail from the rhododendron gardens at Roan High Knob. Trees toppled by wind or scarred severely by lightning testify to the harsh climate.

But the plant communities known as balds evoke the most interest on Roan Mountain. Some area residents still refer to them as slicks because of their shiny appearance from a distance. A.F. Marks, who has studied the southern Appalachian balds thoroughly, defines a bald as "an area of naturally occurring treeless vegetation located on a well-drained site *below* the climatic treeline in a predominantly forested region."

Three kinds of balds occupy the upper slopes of Roan Mountain, all in the zone normally inhabited by the spruce-fir forest. Grass balds are the most common, generally occurring between 5,500 and 5,700 feet. Because they are devoid of most shrubs, they are sometimes called mountain meadows. Mountain oat grass forms a cover through which sheep sorrel, tickle-grass, and wild strawberry occasionally protrude. Some small mounds, called moss hummocks, support the growth only of mosses. At roughly the same altitude are also found the rarest of the Roan Mountain balds, the alder balds, which seem to have developed where there is more available soil moisture. These thick, shrubby stands of three- and four-foot-tall green alders are known from no other area in the Carolinas.

The showplaces of Roan Mountain, however, are the rhododendron balds, located mostly on the southeastern side of the divide at between 6,000 and 6,150 feet. At their peak in mid-June, these balds contain hundreds of brilliant rose-pink catawba rhododendrons, interrupted occasionally by patches of grassland. Here and there, a stray red spruce or mountain ash has established a foothold and overtops the rhododendrons, but few plants grow beneath the shrubs because their densely crowded, thick leaves let little light reach the ground. The rhododendrons also produce a network of feeder roots in the upper two inches of the soil, excluding most herbaceous plants. The Pisgah National Forest has provided parking areas near Roan High Knob, where trails permit visitors to wander through 600 acres of rhododendrons.

Biologists have proposed many theories to explain the origin of the balds. The first

photographs by Jim Bones

Above, a skeleton of a rhododendron grove is one of the treeless areas atop Roan High Knob; opposite, catawba rhododendrons blossom on Roan Mountain.

suggestion, made near the turn of the century, was that balds were areas where the trees had been damaged and ultimately killed by winter ice storms. Although ice does damage some of the trees on Roan Mountain, large acreages of trees would probably not be wiped out while the surrounding forest remained intact. Years ago a prominent Nebraska botanist suggested instead that fire was the primary cause for the development of the balds. In the southern Appalachians, however, fires are normally followed by the invasion of fire cherries, which do not seem to have been an important part of the Roan Mountain flora. The treeless glades and hill prairies of the Midwest are accounted for, at least in part, by their western exposures, which leave them with soil so dry that trees cannot grow. Although many of the balds on Roan Mountain are on southwestern slopes that receive drying winds, their soil is not significantly drier than in the adjacent forests, and trees can grow there if given a chance. Still another suggestion is that Indians cleared the region of trees and maintained the treeless areas for campgrounds and grazing by animals, but there is little evidence of this.

The most plausible explanation for the origin of balds involves past climatic conditions and the reaction of vegetation to them. Typically, the upper elevations of the southern Appalachians support a coniferous spruce-fir forest. Below 5,000 feet, deciduous beech-maple forest prevails. About 4,000 years ago, a lengthy hot and dry period affected the region. The spruces and firs growing near their lower limits of tolerance gradually succumbed to the hot, arid climate and were replaced by beeches and maples. Subsequently, a cooling trend, which has continued to the present, made life difficult for the beeches and maples that had occupied this upper range. Many trees perished during the cold winters, and others fell because of severe winds, ice damage, and possibly even lightning fires.

The spruce-fir forest generally failed to reestablish itself in this zone because any seedlings that germinated soon perished in the absence of a protective tree canopy. The treeless zone was invaded instead by grasses, and the grass balds came into existence. The uppermost balds nearest the spruce-fir forest were eventually populated by rhododendrons, whose seeds came from the rhododendrons in the forest understory. Fir and particularly spruce seeds also fell into these adjacent balds, but the conditions necessary for their germination and survival apparently did not prevail. Those balds that have remained grass balds probably harbor very few rhododendrons because there is not a large rhododendron seed source near by.

Today, the balds of Roan Mountain are unstable communities. Some are expanding; others are shrinking. Where there is expansion, it is because mature trees that grow at the edge of the balds are exposed to more severe environmental conditions than those within the forest. In historical times, also, local settlers who used the balds as grazing areas for their domestic animals cut the bordering trees to provide more space. On the other hand, the edges of the balds are constantly threatened by the invasion of woody plants. The spruces and firs are potent seed sources. A seed may be blown beneath a clump of rhododendrons, whose shade permits the conifer seedling to develop. On occasion, this seedling will grow and break through the shrub canopy, ultimately shading out the rhododendrons and killing them. There is thus a continuous ecological war between the balds and the adjacent forests.

"This Land" highlights the biological phenomena that can be explored in the 153 U.S. national forests. Robert H. Mohlenbrock is professor of botany at Southern Illinois University at Carbondale.

Roan Mountain

Joe Le Monnier

For visitor information write:
Forest Supervisor
Pisgah National Forest
50 South French Broad Avenue
Asheville, North Carolina 28802

The stucco image of a god survives at the Maya site of Kohunlich, in Mexico.
Peter Menzel

The Maya Enter History

Ancient hieroglyphs reveal the life stories and power politics of a ruling elite

by T. Patrick Culbert

The Maya civilization of southern Mexico and Central America has always enchanted both archeologists and the public. The image of giant temple pyramids looming out of the forbidding rain forest and the attraction of an undeciphered script holding unimaginable secrets have helped surround the Maya with an aura of romance. But in recent years, archeological research has stripped away many of the layers of mystery. Most important, as a result of breakthroughs in the interpretation of their hieroglyphic writing, the Maya of the Classic period (A.D. 250–900) have entered history. The names of Maya rulers can now stand beside those of the Pharaohs of Egypt and the legendary kings of Mesopotamia.

The Maya are relative newcomers to the accepted roster of great civilizations of antiquity, for not until the 1840s were their spectacular architectural remains brought to the attention of the public in America and Europe. At that time, New York lawyer and travel writer John Lloyd Stephens, accompanied by the English artist Frederick Catherwood, made two trips into the Maya area to explore some of the most important ruins. His travel books became best sellers in six languages and, for the first time, the educated layperson heard such magic names as Palenque, Copán, and Chichén Itzá.

Stephens was a careful observer who avoided the flights of fancy—the Maya as strayed Phoenicians or lost tribes of Israel, for example—that plagued the accounts of many who followed him into the rain forest. When he sought meaning in the things he encountered, Stephens proceeded cautiously, guided by the evidence and by his knowledge of ancient civilizations in other parts of the world. He reached the logical conclusion that Maya sculptures of individuals were the portraits of "kings, chieftains, or sages" and remarked that some of the hieroglyphs "reminded us strongly of the Egyptian method of giving the names of the kings and heroes in whose honour monuments were erected." Musing upon the site of Copán, he noted, "We considered that in its medallion tablets the people who reared it had published a record of themselves, through which we might one day hold conference with a perished race, and unveil the mystery that hung over the city."

A major exhibition, "Maya—Treasures of an Ancient Civilization," will begin its tour at the American Museum of Natural History, April 26 through July 28. Organized by the Albuquerque Museum of Art, History, and Science, the exhibition features objects on loan from the governments of Mexico, Guatemala, and Belize as well as from United States and Canadian museums. The selection of 275 artifacts, which were recovered from Maya tombs and sites, includes massive carved stone stelae, jade and shell jewelry, golden figurines, and painted ceramics. For the exhibition's complete itinerary, see page 116.

Stephens's hopes were to be long disappointed, however, for research in the century following his explorations turned to such archeological basics as chronology and site description, while the writing system proved intractable to interpreters. Nevertheless, a great deal of information was gained. The Maya calendar, the one readily decipherable part of the inscriptions, showed that dated monuments had been erected between about A.D. 250 and 900—a period promptly dubbed the Classic. This had been followed in the northern half of the lowlands by a vigorous post-Classic period, during which such famous sites as Uxmal and Chichén Itzá saw their major periods of occupation. Excavation at principal sites also revealed levels beneath the Classic remains, showing that centuries of development had preceded the appearance of Classic traits. By the 1940s, archeologists could identify chronological sequences for both ceramic and architectural styles.

Sylvanus G. Morley, dean of Mayanists at the time, listed 116 major sites in a summary of Maya archeology published in 1948. A typical site contained several groups of stone structures, separated from one another by some distance and often connected by impressive paved causeways. Structures were classified as either temples or palaces. Temples were placed atop giant pyramids, which were often taller than modern ten-story buildings. Temple buildings had little usable space, just one to three narrow rooms, arranged one behind the other. Access was through an exterior doorway at the top of a steep stairway, which led up the face of the pyramid. Similar structures were being used for religious ceremonies when the Spaniards first arrived in Mexico in the 1520s.

Palaces were quite different; resting on low platforms rather than pyramids, they were sometimes two or three stories high and had many rooms and entrances. Some archeologists believed these structures were residences for an elite, as implied by the designation *palace*; others thought that they might have been administrative buildings, storehouses, or quarters for priests or students.

Charles Henneghien; Bruce Coleman

The ancient Maya lived in both highland and lowland areas, from what is now southern Mexico through Guatemala, Belize, El Salvador, and Honduras. (Teotihuacan, located near modern-day Mexico City, was a populous non-Maya center whose political influence has been detected at Maya sites.) Classic Maya culture flowered in the lowlands from A.D. 250 to 900. In the ninth century, the civilization collapsed in the central and southern lowlands, and such sites as Tikal, Copán, and Palenque were depopulated. But in the lowlands farther north, as well as in the highlands to the south, Maya groups continued to thrive until the arrival of the Spaniards in the 1520s.

Joe LeMonnier

Because there were no houses between these groups of stone buildings, the impression arose that ancient Maya sites had been vacant ceremonial centers, whose permanent inhabitants consisted of only a small group of elite persons, priests, and craft specialists. Archeologists reasoned that, like modern Maya villages in the neighboring highlands of Guatemala, these centers filled with people only during times of ceremonies, when the lower classes thronged in from the countryside.

Maya art provided more puzzles than answers. Sites were full of stone carvings—upright slabs, or stelae; door lintels; occasional wall panels—that showed elaborately dressed individuals, usually in formal poses. The carvings seemed to be full of religious symbols and sometimes included fantastic, obviously mythological animals, such as the two-headed serpent that writhes through the sky in some compositions. Were the individuals portrayed the kings, chieftains, and sages that Stephens had imagined, or were they instead priests dressed for ceremonies—or perhaps the gods themselves?

The carvings were accompanied by inscriptions, but these resisted decipherment. The Maya calendar had been interpreted by about 1900, and substantial progress had been made in unraveling a complicated series of countings and calculations having to do with calendrical and astronomical events subsidiary to the dates themselves. So it was possible to date carvings and sites with great accuracy, but impossible to say what had gone on at the dates so proudly proclaimed. Since many of the inscriptions dated to the end of Maya calendric periods, especially the end of *katuns* (which were periods of approximately twenty years), the opinion grew that perhaps the Maya had been celebrating the passage of time itself, without reference to historical events.

Despite an accumulation of archeological information, the Maya as people were as remote as ever. As imagined, the elite, nearly alone in their vacant centers, had few concerns about the everyday world and were free to devote themselves to esoteric spiritual matters. They obviously devoted a great deal of energy to erecting mighty temples and presumably using them for ceremonies to honor their gods. They investigated astronomy, mathematics, and calendrics with vigor and an almost compulsive precision. They prayed and philosophized and perhaps celebrated the passage of time, but whether they schemed and struggled for power and material possessions like mortals in most cultures was not clear from the archeological record. Or perhaps such matters were not clear to archeologists, who seemed bent on stressing how the Maya differed from the rest of humankind.

After World War II, the profession of archeology entered a period in which traditional theories and methods were vigorously challenged. New questions were asked and new kinds of data were gathered to answer them. The upshot was that a strong interest in people was added to the customary concern with things. Maya archeology was no exception to this trend. Mayanists, once interested primarily in large stone structures, began to search for the houses of the ordinary Maya.

What they discovered were "house mounds," low dirt platforms surrounded by stone retaining walls. On these the lower classes had constructed houses of poles, with thatched roofs. These building

Left: Temples line the front edge of Tikal's North Acropolis, a huge platform upon which eleven temples stood. The two shown here, stripped of later stages of construction, were built over the tombs of two Early Classic rulers, Curl Nose and Stormy Sky. Below: Chitam, the last identified ruler of Tikal, was honored by this stela (carved tablet) and altar erected in A.D. 77.

Peter Menzel

aterials perished in the steamy jungle nvironment, but postholes had been left the plastered floors, and occasional im-ressions left in mud that had hardened hen houses burned. Maya sites had not een vacant ceremonial centers at all. The eemingly empty spaces between stone uilding groups were crammed with ouse mounds, indicating that tens of housands of inhabitants had lived within alking distance of the centers of the larg-st sites.

This discovery explained where the la-or to build temples and palaces had come om. It also made it less likely that the lite had devoted themselves to philosoph-al speculation, for large communities de-hand organization and administration. dditional data that cried for more orldly interpretations of Maya society ame from major excavations such as the Tikal Project, run by the University of Pennsylvania between 1956 and 1970. Tikal was huge, its population exceeded 30,000, and the indications of kingly splendor were inescapable.

Two tombs and a stela found near the Great Plaza of Tikal were to prove of particular significance in the light of evidence later provided by inscriptions. The tombs, located at the north edge of the Great Plaza, were covered by a succession of major temples. The principal individual in the earlier tomb was accompanied by the skeletons of nine other people, which archeologists interpreted to be sacrifices at the time of death or at the burial ceremonies. In the later tomb a Maya inscription on the wall indicated a date equivalent to March 18, 457. Both tombs included offerings fit for kings: quantities of jade and shell, the bodies of birds, and a profusion of ceramics, including several masterful effigy figures. But the most surprising feature was that both burials included many offerings whose symbolic decoration suggested a connection to Teotihuacan, a vast non-Maya site just outside modern Mexico City, more than 600 miles west of Tikal. Teotihuacan, which emerged as a major Mexican power in the second century, was the most influential site in Mesoamerica until the sixth century.

The puzzle deepened when a stela was discovered during the excavation of a temple that had been built over the site of the dated tomb. The stela, which must have originally stood in some outside location, was from the year 445, close to the date of the 457 tomb. Carved on its face was a typical Maya, garbed in all the finery of Early Classic costume. But this figure was flanked on the two sides of the stela by men who were certainly foreigners. Their faces lacked the characteristic Maya profile, and their costumes were those worn at Teotihuacan. In addition, they carried spear throwers, weapons used in Mexico but not by the Maya, and had shields that showed the face of Tlaloc, the chief god of the Mexicans.

To find Teotihuacan influence in Tikal was not in itself surprising. In the fourth and fifth centuries, Teotihuacan, with a population of more than 150,000, was one of the great cities of the world—a manufacturing and trade center whose products were carried throughout Mesoamerica. But archeologists did not expect to find this influence in the tombs of two of Tikal's most important men or—even more puzzling—on what was regarded as the most sacred Maya medium, a carved stela. What could be the meaning of the apparent encounter pictured on the stela? Pragmatic, commercial, probably militaristic, the representatives of Teotihuacan would not have been dazzled by the Maya's ability to record the passage of time in excruciating detail. If a Tikal lord met with men from Teotihuacan, they must have talked business and power politics.

During the period in which the Tikal Project was producing such marvels, Maya hieroglyphic writing—after decades without significant progress—began to yield to interpretation. The first breakthrough was relatively small, involving just a single class of glyphs, or symbols. In a paper published in 1958, the German epigrapher Heinrich Berlin demonstrated that Maya sites yielded "emblem" glyphs, which named or were otherwise associated with the sites themselves. By itself, Berlin's revelation did not threaten the assumption that the inscriptions dealt almost entirely with ritual and

calendrical calculations, for they might well have been referring to the sites as great ceremonial centers.

The next breakthrough, however, was devastating to the old ideas. In 1960, Tatiana Proskouriakoff, a leading researcher with the Carnegie Institution of Washington, published a paper outlining a pattern she had observed in the inscriptions at Piedras Negras. Proskouriakoff noticed that the stelae, each of which bore a date, had been erected in sets containing from two to eleven stelae. The earliest stela in each set showed a scene that Proskouriakoff dubbed the "ascension motif"—a picture of a man seated in a niche to which a ladder and footprints led. One particular glyph was always associated with this motif. Proskouriakoff deduced that the ascension motif and its associated glyph referred to the inauguration of a ruler, who was pictured taking his throne. She also identified which glyphs named the rulers involved. Later stelae in the set showed the same individual in other activities. Finally, at what was a reasonable length of time for a human life span, the set came to an end and was followed by a new set commemorating the ascension and career of another ruler.

Proskouriakoff's interpretation was so convincingly demonstrated that there was no longer any question that large sections of the Maya inscriptions were historical in character. One revelation followed another. In addition to emblem and name glyphs, glyphs for birth, death, and capture were identified. Rapidly, dynastic lists were developed for prominent sites, including records of outstanding events in the life of each major ruler. The most important sites had been ruled by a series of great families, such as the Sky family of Tikal and the Jaguars of Yaxchilán. These families had been intricately interconnected through marriages and alliances and had continually jockeyed for position in relation to one another and for control and influence at lesser sites.

One story of political maneuvering begins in the middle of the fourth century, when a man named Jaguar Paw ruled Tikal. At Jaguar Paw's death, his son was bypassed, and the throne went to Jaguar Paw's son-in-law, a man called Curl Nose. Curl Nose was not a member of the Tikal royal family; instead, he seems to have originated at Kaminaljuyu, a center in the highlands of Guatemala that was under strong influence from Teotihuacan. The earlier of the two Tikal burials described above, which were rich with symbols of Teotihuacan, belonged to Curl Nose.

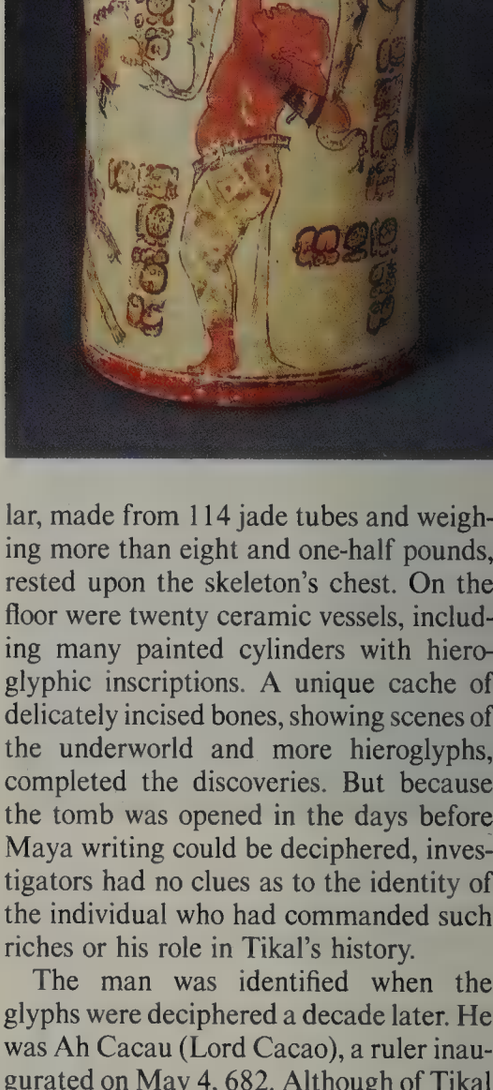
Teotihuacan may well have been powerful enough to influence royal succession in Tikal, first by having a favored leader marry into the ruling family and then by having him crowned king. The inscriptions give no hint of a power struggle, but one can easily imagine a pro-Teotihuacan faction in Tikal arguing vigorously for the benefits to be gained from alliance with the great commercial city. In any case, Tikal became rich and powerful during the reign of Curl Nose. He was succeeded by his son, Stormy Sky, who gained even greater glory as the power of Tikal spread throughout the lowland Maya area. Stormy Sky maintained strong relationships with Teotihuacan, for his was the second burial with Mexican mementos and he is the Maya—flanked by emissaries from Teotihuacan—pictured on the stela. Unfortunately, the parts of the stela's inscriptions that have been interpreted so far provide no details about what event took place at that meeting.

Stormy Sky died about 455, but his influence was to reemerge more than two centuries later. In 1959, Tikal Project archeologists decided to investigate Temple 1, a seventh-century edifice that closes the east end of the Great Plaza at Tikal. By tunneling into the base of the pyramid supporting the temple, they hoped to find a major tomb, for on other occasions tombs had been found on the central axes of temples. The search was a long one, but after more than two years and 400 feet of tunnels, the archeologists came upon the giant limestone slabs that capped the top of the tomb.

When the tomb was opened, their long, painful effort was amply rewarded. Inside lay the skeleton of an elderly male, surrounded by a remarkable store of offerings. Shells, pearls, and large quantities of jade greeted the excavators. A great collar, made from 114 jade tubes and weighing more than eight and one-half pounds, rested upon the skeleton's chest. On the floor were twenty ceramic vessels, including many painted cylinders with hieroglyphic inscriptions. A unique cache of delicately incised bones, showing scenes of the underworld and more hieroglyphs, completed the discoveries. But because the tomb was opened in the days before Maya writing could be deciphered, investigators had no clues as to the identity of the individual who had commanded such riches or his role in Tikal's history.

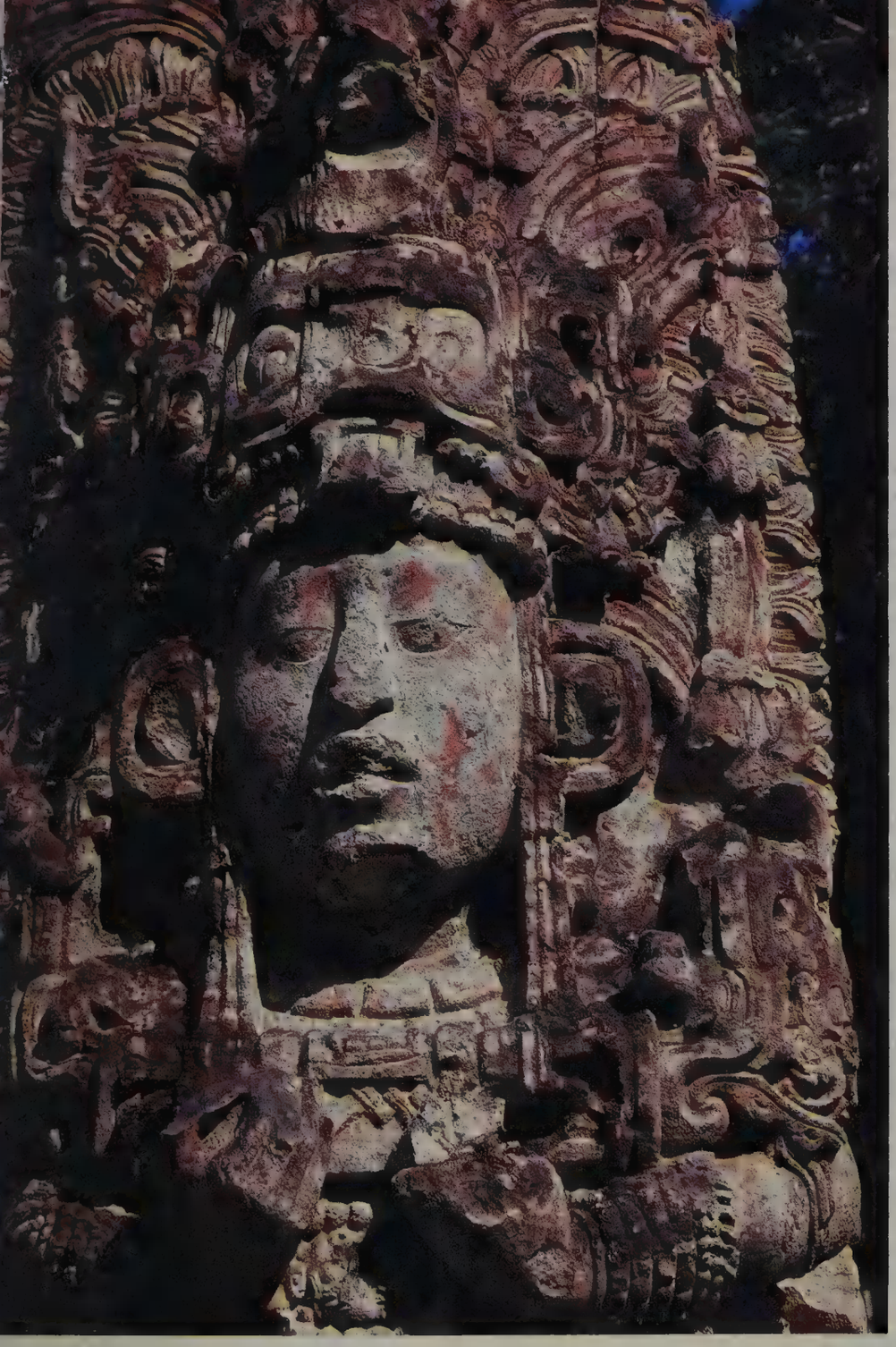
The Altar Vase, recovered from a burial at the site of Altar de Sacrificios, is thought to depict an actual burial ceremony that took place about A.D. 754. The hieroglyphic writing gives some historical information, but it does not identify the snake-handling participant.

Stuart Rome; Courtesy of the National Museum of Archaeology, Guatemala



The man was identified when the glyphs were deciphered a decade later. He was Ah Cacau (Lord Cacao), a ruler inaugurated on May 4, 682. Although of Tikal royal blood, Ah Cacau was not born and raised at Tikal. He seems to have been a member of a branch of the royal house that had left the site some time earlier, perhaps during a period of political turmoil. The most important feature of his ancestry was that Ah Cacau was—or at least asserted he was—a direct descendant of Stormy Sky, in whose legendary mantle he proudly wrapped himself.

Ah Cacau's predecessors are not well known, for there is a long gap in the Tikal inscriptions. One interpretation, however, is that Ah Cacau took the throne by force



B. Kielczynski; The Stock Market

A stela from Copán, in the deeply carved style characteristic of that site, shows a Maya noblewoman of A.D. *726. Women are rarely depicted in formal Maya art; this one may have been the wife of the Copán ruler.*

om someone he considered a usurper. Whatever the circumstances of his acquisition of power, Ah Cacau stressed the legitimacy of his rule and traded upon the reputation of his ancestor Stormy Sky. The Maya calendar offered him an unusual opportunity to do so, for thirteen *katuns* (about 260 years) had passed since Stormy Sky's inauguration. At that interval, the calendar reached the end of a cycle and began over again. Because the Maya believed that history was cyclical, they anticipated that events of the previous cycle would be repeated. In choosing the thirteen-*katun* anniversary of Stormy Sky's inauguration for his own inauguration, Ah Cacau implied that his reign would rival that of his fabled predecessor. Such proved to be the case, for he led the city into what was to be the period of its greatest glory. Major construction was undertaken during Ah Cacau's reign, and in the eighth century Tikal emerged from a period of relative political obscurity to become one of the most powerful Maya sites.

Maya art takes on new meaning now that scholars know it depicts historical characters rather than priestly ceremonies or gods. The carved stela is the most formal medium the Maya used to glorify their elite. Most stelae portray the stiffly posed ruler bearing the elaborate costume and insignia of office. Additional scenes, accompanied by inscriptions, were carved on the lintels and wall panels found at certain sites. These scenes, involving several characters, portray ceremonies of investiture, battles, and subjects kneeling before their ruler.

Between 600 and 800, the Maya began making a type of multicolored painted pottery that sometimes showed historical and mythological characters in a variety of lively activities. These scenes, usually painted on cylindrical vessels found only in the richest of burials, include some of the great masterpieces of Maya art. Among the most famous is the Altar Vase, recovered from a woman's burial at the medium-sized site of Altar de Sacrificios. The vase depicts a burial ceremony. Two people are shown dancing, a man in jaguar-skin tights and a bald, pudgy individual holding aloft a giant snake. Four seated people watch the proceedings. The glyphs suggest that the ceremony was attended by representatives from several large sites. The dancing figure in jaguar costume is identified as Bird Jaguar, a ruler from Yaxchilán, while one of the seated individuals is from Tikal. Apparently the woman whose burial ceremony is pictured was related to the dynasties at both these sites, and both sent representatives to the funeral.

The participation of outside representatives at burial ceremonies is also evident at the tomb of Ah Cacau at Tikal. Among the offerings in the tomb was a set of nine painted cylinders, each portraying a king seated upon a throne. These are not portraits of Ah Cacau, for both the pictures and inscriptions indicate they are other lords. Furthermore the paintings are not the work of master artists. Instead, they range from a few pieces of acceptable quality to some of excruciatingly bad workmanship. A plausible explanation for why vessels that display such an abysmal lack of talent should have been placed in the tomb of one of the most important Maya leaders is that they were done personally by visiting rulers as a mark of respect for their departed colleague.

Archeological views of the Maya have changed drastically in a single generation. From a remote and mysterious people ruled by holy priest-kings devoted to lofty philosophical speculations, they have been transformed into a historical reality whose dynasties have names as familiar to specialists as those of the Ramses and Hapsburgs. In the process, Maya kings have gained humanity. They engaged in political intrigues, married for power and profit, and were as obsessed that future

generations should know of their greatness as were the kings of other civilizations.

These new insights, combined with archeological data on site size, structure, and location, have given us a much better understanding of Maya civilization at its height. In the Late Classic—the period from which most of the inscriptions date—the lowland Maya area apparently was divided between some half dozen regional states. Major sites such as Tikal, Palenque, and Copán served as capitals, with secondary sites bound to them through conquest, alliance, and elite intermarriage. The political structure may have been feudal, with paramount rulers at the capitals struggling to maintain the loyalty of unruly hordes of lesser nobles.

We do not know why Maya civilization disappeared from the central and southern lowland region in the ninth century. Inscriptions ceased, new construction halted, and a massive decline in population left huge areas almost unpopulated. In light of the climax reached by the Classic Maya, this collapse seems even more profound.

Both the success and the failure of the Classic Maya must have had roots in the activities of the humble people revealed by archeological research. The number of house mounds dating to the Late Classic leaves no doubt that the population had become extremely large—far too large to have been supported by the simple slash-and-burn agriculture generally regarded as the soundest approach to farming in the rain forest environment. Archeological remains indicate that extensive systems of terraces were constructed in parts of the lowlands and that large tracts of low-lying seasonal swampland were converted into farmland by digging drainage canals. This high level of population and production may well have overtaxed the fragile rain forest environment. But the activities of the Maya rulers are also at issue, for problems of management and control must have become acute as the population grew. The failure of the elite to develop techniques for the successful management of a rapidly expanding system may have been an equally critical factor in the Maya collapse. □

The Adivino, the House of the Magician, is a typical temple, a small building atop a pyramid. It was built about A.D. 800–1000 at Uxmal, a center in the northern lowland zone.

David Alan Harvey; Woodfin Camp & Associates

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State of the Earth

Nearly five billion, and growing, we are straining earth's environment to an unprecedented degree. As human pressures build, the relationships between people and their natural support systems reach key

Illustrations by Alan E. Cobe

thresholds, leading to breakdowns. The broad strokes of this mid–decade report often show a frightening drift in a gloomy direction. Yet some fine strokes show bright examples of moves toward a healthy, sustained balance between humans and their natural resources. Our decisions and actions (or inactions) in the remaining years of this decade will affect the fate of all life on earth in the next decade . . . and century. In concert, we will determine whether we are breaking down or breaking out.

Nowhere is the breakdown of natural systems more tragically evident than in Africa, where famine is spreading rapidly. In 1970, Africa was essentially self-sufficient in food; by 1984, however, some 140 million Africans—out of 531 million—were fed with grain from abroad. The decline in per capita food production has been attributed to drought, but the causes are more fundamental: the fastest population growth in history, widespread soil erosion, and the neglect of agriculture by African governments.

The deterioration of environmental systems can be seen in industrial and developing countries alike. Acid rain and air pollutants may be destroying the forests of central Europe even faster than the ax and the plow destroyed those of India and El Salvador. Little attention has been paid to the economy–ecosystem relationship, and our understanding of stresses on ecosystems is far from complete.

National energy policies could determine the extent and pace of a worldwide change in climate. Population policies may determine whether Africa becomes a wasteland. The scale of environmental disruptions we face lends urgency to our efforts to return to a sustainable path—to bring population growth and our economic and social systems into a long-term balance with the resource base that supports us.

Lester R. Brown

Erosion of productive soils by wind and water is changing the face of

the earth, from subsistence fields in Ethiopia's highlands to thousand-acre swaths of corn and soybeans in the Mississippi valley. One of the first scientists to assess the dimensions of world soil erosion was geologist Sheldon Judson, who estimated that the amount of river-borne soil sediment carried into the oceans had increased from 9 billion tons per year before the introduction of agriculture and grazing to 24 billion tons per year in the late twentieth century. Humans have accelerated the flow of soil to the seas.

Soil erosion is steadily speeding up and now afflicts both industrial and developing countries. Only the ninefold increase in fertilizer use and the near tripling of the world's irrigated cropland since mid-century have masked the effects of soil erosion on crop yields and harvests. Yet as of 1984, the worldwide loss of topsoil from cropland in excess of new soil formation totaled some 25 billion tons.

Topsoil is the key to productive agriculture. Rich in organic matter, it shares more characteristics with the plant life it supports above than with the mineral layers beneath. It is the medium in which roots grow, soil animals flourish, and water is stored. Although in a few regions fertile soils are yards deep, over most of the world's surface the mantle of topsoil on which agriculture depends is only six to eight inches thick. The loss of this thin layer may soon compromise economic progress and political stability.

While detailed information on soil erosion from farmers' fields is available for only a few countries, data on the sediment load of the world's major rivers and on the movement of wind-borne soil over the oceans do provide a broad-brush view of soil erosion at the continental level. Chinese scientists report that the Huang He (Yellow River) carries 1.6 billion tons of soil to the ocean each year. India's Ganga River deposits 1.5 billion tons into the Bay of Bengal. The Mississippi, the largest U.S. river, carries 300 million tons of soil into the Gulf of Mexico each year. Although less than Asia's rivers, this load is soil from the agricultural heartland and is thus a major concern of U.S. agronomists.

Scientists have recently documented that vast amounts of wind-borne soil are also being deposited in the oceans. Island-based air sampling stations in the Atlantic, along with satellite photographs, indicate clearly that plumes of soil dust are being carried out of north Africa over the Atlantic. African soil spatters cars in Miami. Researchers link the unusually high levels recorded in 1983 to Africa's severe drought. Air samples taken at Mauna Loa, Hawaii, indicate a comparable transport of soil across the Pacific from the Asian mainland. The annual peaks in the samples (in March, April, and May) coincide with periods of strong winds, low rainfall, and plowing in the semiarid regions of north Asia. Scientists at Mauna Loa can now tell when spring plowing starts in north China.

The steady growth in demand for agricultural products contributes to soil erosion in many ways. Throughout the Third World, farmers are pushed onto steeply sloping, erosive land that is rapidly losing its topsoil. In the American Midwest, many farmers have abandoned ecologically stable, long-term crop rotations in favor of the continuous row

Kenya: Trees and Terraces to the Rescue

Kenya may be the only Third World country to launch a successful national program to conserve its soils. A decade old, the program shows not only that conservation is compatible with small-scale farming and a large rural population but also that such improvements can boost farmers' incomes.

Kenya identified soil erosion as its most serious environmental problem when preparing for a United Nations conference in 1972. With technical and financial aid from Sweden, the Kenyan Ministry of Agriculture launched several local projects in 1974. The program encouraged farmers to plant fruit, fuel, and fodder trees and to construct simple terraces on their fields to reduce the runoff of water.

By 1983, more than 100,000 farms had enrolled in the program, and 30,000 to 35,000 more farms were being added each year. Miles of newly constructed terraces to catch moisture and cutoff drains to divert erosive flows covered a distance equal to that between Sweden and the Cape of Good Hope. This success was achieved by involving farmers in the design of the program from the outset, providing them with seedlings of valuable trees, and establishing that crop yields could be increased in the short run. Higher yields reflected not only the saving of soil but also the retention of water and nutrients behind terraces.

The Kenyan experience demonstrates that a Third World country with limited financial resources can design and carry out an effective national soil and water conservation program with a minimum of outside aid. The significance of this achievement goes far beyond Kenya, for it means that other developing countries can mount an effective response to this serious agricultural problem.—*E.C.W.*

cropping of corn and soybeans, which leaves soils exposed to wind and water. In other areas, farming has extended into semiarid regions where land is vulnerable to wind erosion when plowed.

The loss of topsoil has two effects on farmers' ability to grow food: It robs the land of nutrients, and it degrades physical properties of the soil, such as its ability to absorb water. Erosion also increases the costs of food production. When farmers lose topsoil, they may increase land productivity by substituting energy in the form of fertilizer or through irrigation to offset the soil's declining water-absorptive capacity. Farmers losing topsoil may experience either a decline in their land's productivity or a rise in their costs. And when this happens, farmers can be forced to abandon their land.

The effects of erosion on harvests are not easily measured since they are usually gradual and cumulative. A survey of independent studies of soil erosion in the U.S. Corn Belt found that the loss of an inch of topsoil reduced corn yields by three to six bushels per acre. The average of these yield reductions was 6 percent. Results for wheat showed a similar relationship: Up to two and one-half bushels of wheat were lost on each eroding acre, yielding an average decline of 6 percent. At current rates, an inch of topsoil is lost from Iowa's cornfields and Montana's wheat fields every fourteen years. What are the long-term implications of erosion? One study, designed to predict the consequences of soil depletion in southern Iowa, showed that steady, uncontrolled soil loss would severely reduce yields of corn, oats, and soybeans, sacrificing as much as a third of the potential productivity of these crops.

Some governments have failed to support soil conservation enthusiastically because they do not see the link between topsoil losses and land productivity. Fortunately, new analytic tools are becoming available to scientists and policy makers. A method for calculating the ratio between actual and potential crop yields at various levels of soil loss has been developed for soils in the United States and is being tested on tropical soils in Hawaii, India, Mexico, and Nigeria. Its usefulness in estimating the global impact of erosion awaits a painstaking inventory of the world's soils.

The National Resources Inventory in the United States, conducted first in 1977 and then in 1982, is the most comprehensive national soil survey ever undertaken. Preliminary results for 1982 show that 44 percent of U.S. cropland is losing topsoil in excess of its tolerance level, a level roughly equal to the slow rate of soil formation. More than 90 percent of the soil eroding at excessive rates is on less than one-quarter of the cropland. These results attest to the need for action and point out where conservation efforts can most profitably be focused.

Two other major food-producing countries, China and India, have estimated their excessive soil loss. A study prepared for the Chinese government reports that five billion tons of soil and sand are washed into rivers each year. The government of India estimated in 1976 that soil degradation affected 370 million acres. Indian soil scientists concluded that the nation's croplands were losing a total of six billion tons of soil each year.

Despite considerable evidence of excessive soil erosion in the Soviet Union, the world's fourth major food producer, no comprehensive national survey has been undertaken. The best indirect evidence of pressures on Soviet soils is the 1984 decision to fallow more than 52 million acres of cropland, the highest level since the sixties. Despite expected grain imports of more than 50 million tons—the most by any country in history—the Soviets have decided to pull land out of production.

Although the changes in agricultural practices needed to check excessive soil erosion can be implemented only by farmers themselves, bringing erosion under control requires government involvement. Many farmers cannot easily determine whether their erosion is excessive. Measuring the

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gradual loss of soil requires scientific techniques and equipment; determining whether it is excessive requires information on tolerance levels for the particular cropland in question. Too, individual farmers may be unable to afford the necessary conservation practices. It may make sense for society to invest in soil conservation even if it is not profitable for the individual farmer. Only governments can calculate the long-term costs of soil erosion for a nation as a whole, including off-farm costs such as the siltation of irrigation reservoirs, hydroelectric reservoirs, and navigable rivers.

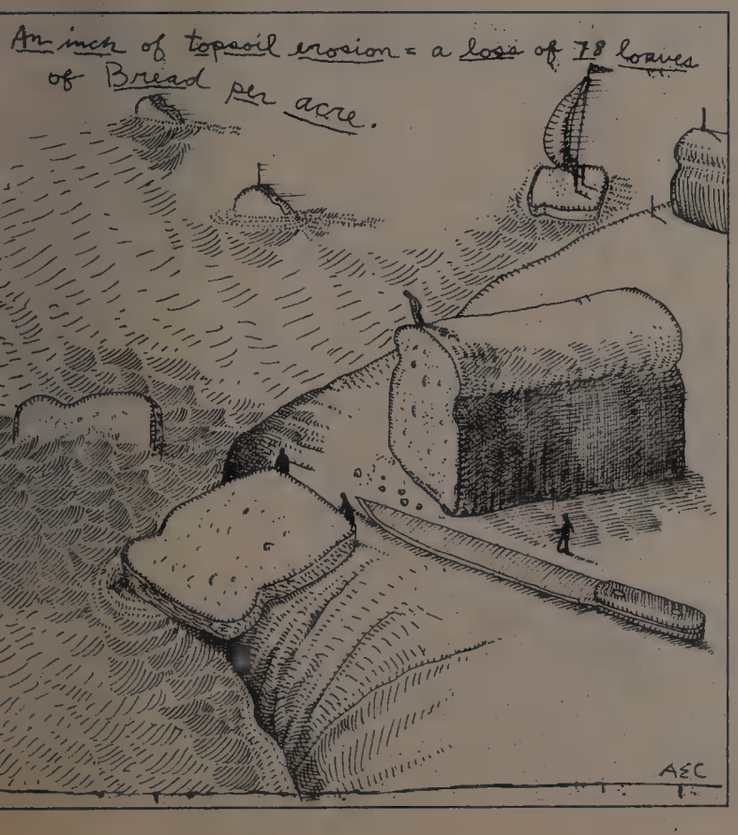
The United States unilaterally attempts to balance the world's supply and demand of agricultural commodities by withholding land from production during times of surplus. But little or no effort has been made to coordinate farm supply management programs that divert land with conservation programs designed to reduce soil erosion. Highly eroded cropland could be diverted to other uses, such as fuelwood production or grazing. This could bring the production of some grains down to a level that would reduce the need for government price supports and revive the profitability of farms.

In efforts to conserve soil, the world is faring poorly. There are few national successes, few models that other countries can emulate. The United States has the technology, the detailed information on its soil losses, and the resources to launch an exemplary soil conservation program, but it lacks committed leadership. Within the Third World, Kenya is one of the few countries to launch a successful national program to conserve its soils.

Over the past generation, many countries have, like Kenya, become unable to harvest enough to feed their people, but few have linked the shortages with the depletion of their soil by erosion. In many countries, people know that food prices are rising, but most do not know why. Understanding that lost soil means lower inherent productivity, which in turn means costlier food, is an important first step toward an international soil conservation ethic.

Uncontrolled soil erosion will eventually lead to higher food prices, hunger, and quite possibly, persistent pockets of famine. Although the world economy has weathered a severalfold increase in the price of oil over the past decade, it is not well equipped to cope with even modest rises in the price of food. The immediate effects of soil erosion are economic, but the ultimate effects are social.

Edward C. Wolf



Shocking glimpses of famished drought victims dramatize water's crucial

role in meeting basic human needs in Africa. And water shortages are persistently, if less dramatically, turning up throughout the world, posing far-reaching threats to our future food supplies and to economic progress.

By virtue of a cyclic flow between the sea, air, and land, fresh water is an abundant, renewable resource. Each year, the sun's energy lifts some 500,000 cubic kilometers of water from the earth's surface—86 percent from the oceans and 14 percent from land. (One cubic kilometer equals about 264 billion gallons.) An equal amount falls back to earth as rain, sleet, or snow, but fortunately a greater share falls over the land than is evaporated from it. The net effect of this solar-powered cycle is to distill and transfer 41,000 cubic kilometers of water from the oceans to the continents each year. To complete the natural cycle, this water then makes its way back to the sea as runoff.

Viewed globally, fresh water is undeniably abundant and seems to defy notions of scarcity: The world's total renewable supply could support the material needs of five to ten times the existing world population. But these supplies are not always available where and when they are most needed. Moreover, unlike oil, metals, or wheat, water is not a global commodity—one that is easily traded internationally. If current trends continue, excessive water use in several of the world's major crop-producing regions may undermine the future capacity of the world to feed itself.

One-fifth of U.S. irrigated cropland is supported

by a water supply that is diminishing. For several decades, many farmers in the High Plains have irrigated their corn, sorghum, and cotton fields by pumping water from the Ogallala Aquifer, a vast underground reservoir stretching from southern South Dakota to northwest Texas. Much of the Ogallala's water is thousands of years old and gets little replenishment from rainfall. Over the last four decades, 132 trillion gallons have been withdrawn, and hydrologists estimate that the aquifer is now half depleted beneath large portions of Texas, New Mexico, and Kansas. As water tables fall, farmers faced with rising pumping costs and diminishing well yields are taking land out of irrigation. After nearly four decades of steady growth, the total irrigated area in the six states that rely most heavily on the Ogallala is now declining. Without a concerted effort to slow it, the Ogallala's depletion will continue. Much of this water is being used to grow crops of which the nation now has a surplus. When needed to meet vital future food needs domestically or abroad, this water may not be available.

Nearly half the irrigated area in the Soviet Union is located in the central Asian republics and Kazakhstan. Water supplies for the region come primarily from two rivers, the Amu-Dar'ya and the Syr-Dar'ya, and in dry years, virtually all the available water is used. These two rivers are also the main source of inflow to the Aral'skoye More (Aral Sea), helping to replenish the water lost to evaporation. Just as falling water levels are signaling water stress in the U.S. High Plains, the shrinking Aral'skoye More testifies to the shortage pending in central Asia: Heavy irrigation withdrawals from the Amu-Dar'ya and the Syr-Dar'ya have caused the sea's level to drop 29.5 feet since 1960, and its volume may be halved by the turn of the century.

In China, also among the world's three major grain producers, a water deficit is worsening in the northern provinces. The north China plain yields 25 to 30 percent of the value of China's crop output, besides supporting the large populations of Beijing and Tianjin. Groundwater pumping in the Beijing area now exceeds the sustainable supply by one-fourth, and water tables in some areas are falling as much as three to thirteen feet per year.

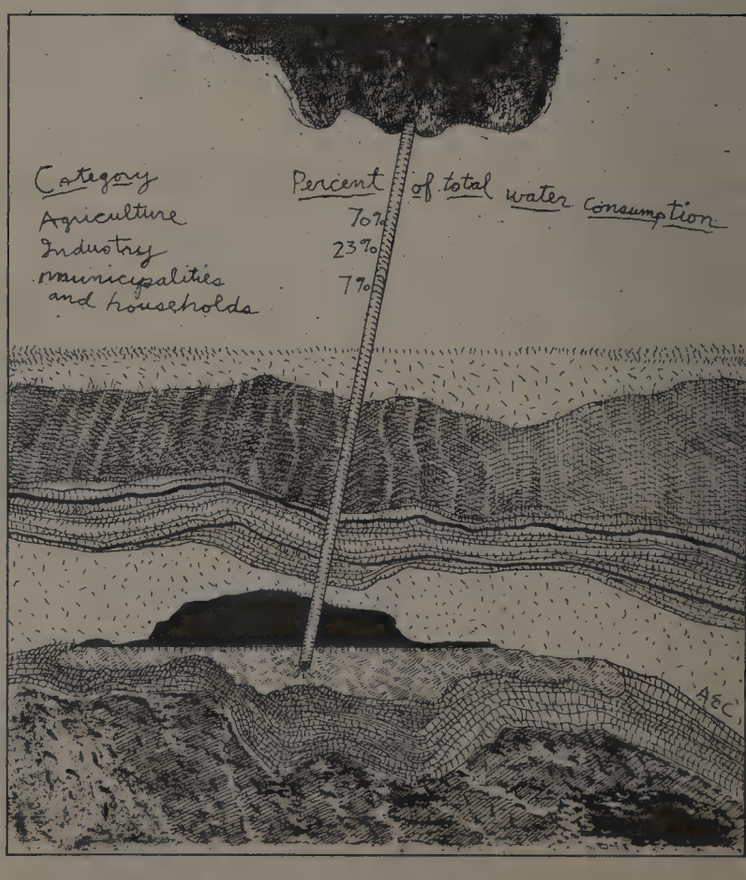
Historically, when natural water supplies became inadequate to meet a region's demands, water planners and engineers built dams to capture and store runoff that would otherwise flow through the water cycle "unused," and they diverted rivers to redistribute water from areas of lesser to greater need. Engineering feats, such as Egypt's Aswan Dam and the California Aqueduct, have literally made deserts bloom. But today many countries are finding that the list of possible dam and diversion sites is growing short and that the cost of developing new supplies is rapidly increasing.

China, the Soviet Union, and the United States have each examined large schemes for diverting water from a distant river basin to increase the supplies of their water-short agricultural regions. When the U.S. Army Corps of Engineers looked at the possibility of transferring water from midwestern rivers to the High Plains, it found that the costs were far higher than farmers would be willing to pay. Tight capital and $180-billion federal deficits are now forcing to an end the long era of massive water subsidies that allowed such uneconomical projects to materialize in the past. Consequently, prospects are dim that distant water will save irrigated agriculture atop the Ogallala.

Both China and the Soviet Union are proceeding cautiously with plans for river diversions unprecedented in scale. The Chinese have apparently begun construction on a 700-mile diversion of the Chang Jiang (Yangtze) River northward to the north China plain. The Soviets are preparing detailed engineering designs for a 1,500-mile diversion of north-flowing Siberian rivers south into central Asia. A final decision as to whether to proceed with construction—estimated to cost a daunting $41 billion—is expected in 1986. Yet even this grandiose scheme will meet only one-fourth of the water deficit projected for Soviet central Asia.

Thus far, water planners have paid little attention to the demand side of the water equation. But now that the economic and environmental costs of traditional supply-side strategies are becoming prohibitive, a fundamental shift toward reducing water demand offers the best prospect for alleviating water constraints.

Since agriculture claims the bulk of most na-



srael: The Thrifty Irrigator

Although the history of drip irrigation goes back to experiments in Germany in the 1860s, Israel pioneered the technology's commercial development during the last three decades. A drip system typically includes an extensive network of perforated plastic piping that is installed on or below the soil surface. Because water is delivered more directly to the crop's root zone, less water evaporates and is lost from the field. Another advantage is that soluble fertilizer can be added directly to the irrigation water, thereby cutting the amount of chemicals spread over the field and lessening the chance of groundwater contamination. With plants receiving optimum amounts of water and nutrients, crop yields can increase. Experiments with drip in Israel's Negev Desert have shown per acre yield increases of 80 percent over sprinkler systems.

Israel also pioneered the development of automated irrigation, in which the timing and amount of water applied are controlled by computers. The computer not only sets the water flow; it also detects leaks, adjusts water application for wind speed and soil moisture, and optimizes fertilizer use. Motorola Israel Ltd., the main local marketer of automated systems, recently began exporting its product; by 1982 more than 100 units had been sold in the United States. Israel's overall gains in agricultural water-use efficiency, through widespread adoption of sprinkler and drip systems and optimum management practices are impressive: The average volume of water applied per acre declined by a fifth between 1967 and 1981, allowing the nation's irrigated area to expand by 39 percent while farmers' water withdrawals grew by only 13 percent.—*S.P.*

tions' water budgets—and 70 percent of water withdrawals worldwide—saving even a small fraction of this water frees a large amount to meet other needs. Raising irrigation efficiencies worldwide by just 10 percent, for example, would save enough water to supply all global residential water uses. Vast quantities of irrigation water seep through unlined canals while in transit to farmers' fields, and much more water is typically applied to crops than is necessary for them to grow. Even in a technologically advanced nation such as the United States, irrigation efficiencies are often less than 50 percent.

Most farmers irrigate their fields with gravity-flow systems, the oldest method and generally the least expensive to install. Water seeps into the soil as it flows across a gently sloping, sometimes furrowed field. Without careful management, a large share often percolates to great depths or runs off the field. Only a small portion remains in the root zone, where the crops can use it. Sprinkler systems, which come in many varieties, deliver water in a spray. They are typically more efficient than gravity systems, but since they operate under pressure, they require much more energy. One design—the center-pivot system—was largely responsible for the rapid expansion of irrigation on the U.S. High Plains in recent decades. Drip irrigation systems release water close to the plant's roots, thereby minimizing evaporation and seepage losses. Although expensive, carefully designed and operated drip methods often use 30 to 50 percent less water than conventional gravity systems.

With the exception of countries such as Israel, which is already using 95 percent of its freshwater supplies, most governments still treat water as a limitless resource. U.S. farmers supplied with irrigation water from federal projects, for example, pay on average less than one-fifth of the real cost of supplying it. Taxpayers are burdened with the remainder, and farmers have little incentive to adopt water-conserving irrigation methods.

But at least one example worth emulating has emerged in the United States: the 1980 Arizona Groundwater Management Act. Facing a rapidly dwindling groundwater supply, Arizona is requiring its most overpumped areas—including Tucson and Phoenix—to achieve "safe yield" by the year 2025. At this level, no more groundwater is withdrawn than is recharged; the resource is thus in balance. Conservation measures will be required of all water users and all groundwater pumping will be taxed. If, by the year 2006, it appears that conservation alone will not achieve the state's goal, the government can begin buying and retiring farmland. The state's water supplies simply cannot support both a booming population and a water-thirsty farming economy for long.

Although agriculture is the biggest water consumer, conservation in cities can greatly reduce the cost of pumping and treating household water, besides delaying the need to develop more costly supplies. Several states, including California, Florida, Michigan, and New York, now have laws requiring the installation of various water-efficient appliances in new homes, apartments, and offices. A 1983 California law also requires every urban water supplier in the state to submit by the end of 1985 a management plan that explicitly evaluates efficiency measures as alternatives to developing new supplies.

In an era of growing competition for limited water sources, heightened environmental awareness, and scarce and costly capital, new water strategies are needed. Alternatives to large dam and diversion projects exist, and water crises need not occur. Failing to take steps toward a water-efficient economy is risky: Future food needs may go unmet, industrial activity may slow, and the rationing of drinking-water supplies may become more commonplace. Conservation and better management can free a large volume of water—and capital—for competing uses. Thus far, we have seen only hints of their potential.

Sandra Postel

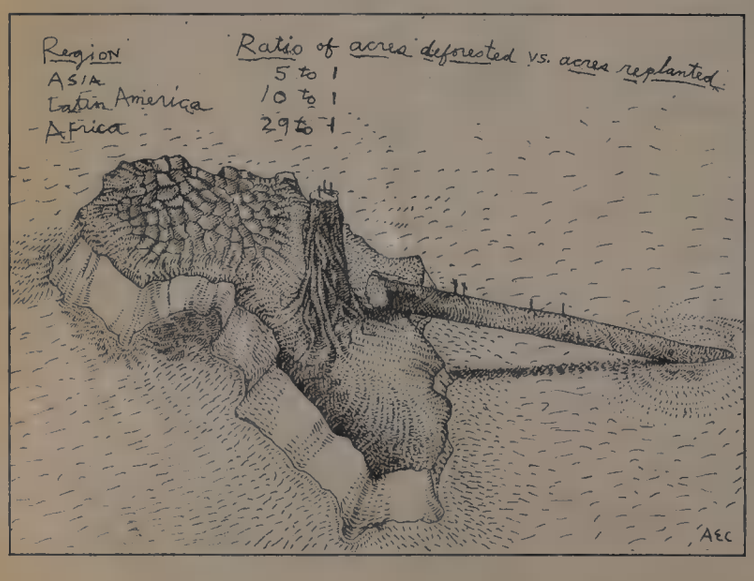
The earth's forest systems are collapsing under two different sets

of pressures; in the tropics, 76,000 acres of trees are cleared daily—an annual loss of forested area nearly the size of Pennsylvania. And in the northern tier of industrial countries, damage linked to air pollutants or acid rain affects trees covering more than 12 million acres—an area the size of New Jersey and Maryland combined.

Wooded lands of all types cover 12 billion acres, an area more than triple that in crops. Tropical America, Africa, and Asia account for 60 percent of the total, and it is in these regions that large-scale clearing of forests is taking place. Unabated population growth is causing conversion of forest to cropland as more and more rural families try to survive on increasingly marginal land. Some replacement of trees with crops is clearly essential to increase food production, but the tragedy in the tropics is that forests are often cleared either where soils are too infertile to sustain crop production over the long term or in a manner that prematurely depletes the land's productive capacity.

Shifting cultivation, which for centuries provided a sustainable agricultural system, has broken down with the population buildup of recent times. Traditionally, farmers would clear some forest, grow crops until the soil became too deficient in nutrients, and then clear a new area, returning to the original plot perhaps twenty years later. By then, the land had lain fallow long enough to restore its fertility. But in many areas, population densities no longer allow for the twenty-five to fifty acres of land per person needed to sustain this farming system. The land is overused, additional forests are cleared on soils that cannot sustain crops, and destruction spreads.

Fuelwood gathering, timber harvesting, and in Central America, conversion of forest to pasture are other forces behind deforestation. As forests dwindle, signs of scarcity grow, taking an especially large toll on the third of humanity for which firewood is the only source of cooking fuel and warmth. In many west African and Central American towns and cities, a typical family may spend one-quarter of its earnings on fuelwood and charcoal, comparable to what a family in an affluent society might spend on housing.



According to the United Nations Food and Agriculture Organization (FAO), more than 100 million people—half of them in Africa—cannot get enough fuelwood to meet their basic needs. Nearly 1.2 billion people are meeting their needs only by overcutting and depleting their forest resources, an unsustainable practice. FAO projects that by the year 2000, more than half the people of the developing world will be in one of two categories—either lacking sufficient firewood or meeting their needs by depleting the resource.

Rarely valued monetarily, the loss of the ecosystem services provided freely by a natural forest entails real economic and social costs. An intact forest moderates the water cycle, allowing rainwater to infiltrate the soil. Especially in regions subject to the extremes of a monsoon climate, deforestation and the loss of this buffering effect worsen flooding, drought, and soil erosion. The cost of repairing flood damages in India below the Himalayan watershed has recently averaged $250 million per year. In the Philippines, a government report blamed deforestation for frequent flooding, erosion, river siltation, and a loss of water supplies. Silting of the reservoir behind Ambuklao Dam has halved the hydropower plant's useful life.

Putting forestry on a sustainable footing in the Third World requires addressing deforestation's underlying causes: excessive population growth, landlessness, and the shortage of productive livelihoods for the rural poor. Recently, some projects have made forestry more responsive to people's needs. In the Indian state of Gujarat, the government has offered free seedlings to farmers, and tree farming is providing a stable source of income. Another approach, agroforestry, integrates tree and crop plantings for combined fuel and food production. In the Kordofan region of Sudan, where desertification and firewood shortages are severe, efforts have focused on restoring the traditional practice of growing nitrogen-fixing acacia trees along with food crops.

China and South Korea have each mounted national tree-planting campaigns to reclaim vast areas of degraded land. China's official goals are to increase its forest cover from 12 percent to 20 percent by the year 2000 and ultimately restore trees to one-third of its territory. South Korea had rapid success with a replanting program begun in the

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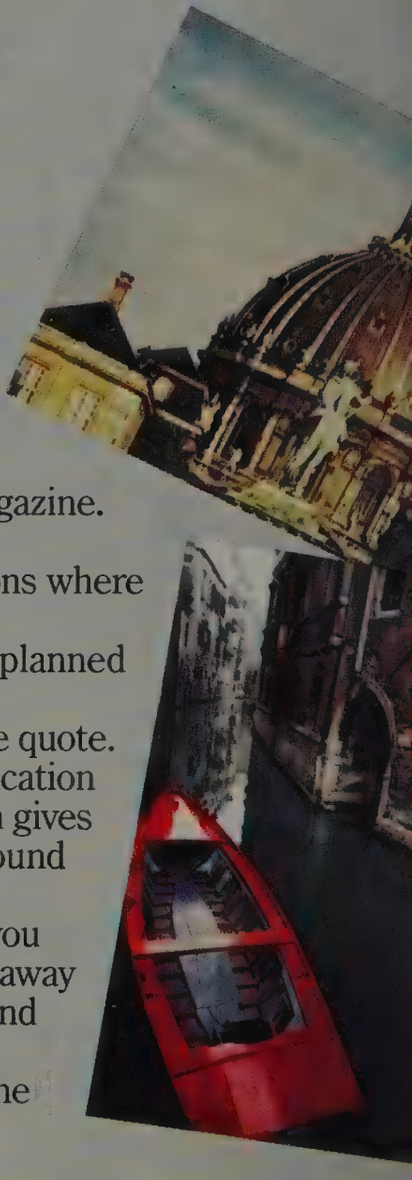

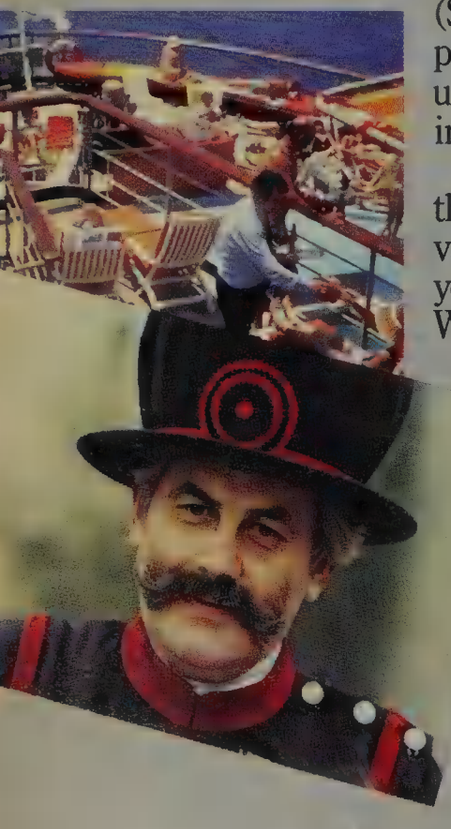

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early seventies. In just a few years, trees were established on an area more than half that in rice, the country's food staple.

Unfortunately, the political will and commitment of resources needed to break the cycle fostered by deforestation is lacking in much of the tropical Third World. At present, only one acre of trees is planted for every ten acres cleared. The gap is greatest by far in Africa, where the ratio of tree clearing to planting is twenty-nine to one. Meeting the Third World's projected fuelwood needs by 2000 would require a thirteenfold increase in the current rate of tree planting for nonindustrial uses.

While lack of economic progress drives deforestation in the Third World, the byproducts of industrialization are threatening forests in the temperate zone. In the past decade, it has become evident that air pollutants from the combustion of fossil fuels—both oil and coal—and the smelting of metallic ores are undermining sensitive forests and soils. Many forests in Europe and North America now receive thirty times more acidity than they would if rain and snow were falling through a pristine atmosphere. Ozone levels in many rural areas of Europe and North America are now regularly in the range known to damage trees. Acting alone or together, several pollutants—including acid-forming sulfates and nitrates, gaseous sulfur dioxide, ozone, and heavy metals—are placing forests under severe stress. Needles and leaves yellow and drop prematurely from branches, tree crowns progressively thin, and ultimately, trees die. Even trees that show no visible sign of damage may be declining in growth and productivity.

In just a few years, forest damage has spread with frightening rapidity through portions of central Europe. No nation has better documented the destruction within its borders than West Germany, where forests cover roughly a third of the land area. The government's most recent survey shows that half the nation's trees are injured, and so far the destruction shows no signs of abating. (See box.) A total of 2.4 million acres are affected in Poland and Czechoslovakia. Environmental scientists have warned that by 1990 more than 7 million acres of Poland's forests may be lost if the nation proceeds with its present industrialization plans, which call for increased burning of the nation's high-sulfur brown coals.

Damage reported in other European countries, including Austria, Switzerland, the Netherlands, East Germany, Romania, and Sweden, adds to the growing evidence of unprecedented forest devastation. In the United States, from the Appalachians of Virginia and West Virginia northward to the Green Mountains and White Mountains of New England, red spruce is undergoing a serious dieback—a progressive thinning from the outer tree crown inward. Damage is most severe in the high-elevation forests of New England. By the spring of 1984, researchers had detected serious spruce damage as far south as North Carolina's Mount Mitchell—the highest peak in eastern North America—and tree deaths were expected to be identified in other areas soon thereafter.

Recent publicity about acid rain has tended to lump this forest destruction with acidifying lakes, dying fish, and other effects of acid rain. Forest damage has added impetus to calls to reduce emissions of sulfur dioxide, the primary acid rain precursor. Indeed, fifteen European countries and Canada have made formal commitments to reduce sulfur emissions by 30 percent or more by the early nineties; notably absent from this "30 percent club"

West Germany: Death of a Fairy Tale Forest

West Germany's forests are not just sources of lumber and pulp—they helped shape the nation's cultural and literary heritage. The loss of these woodlands is a potent political and emotional issue for West Germans. *Waldsterben*—or forest death—is now a household word. A survey in the summer of 1983 showed that West Germans were more concerned about the fate of their forests than about the Pershing missiles to be placed on their land later that year.

Following a 1982 forest survey, the federal minister of food, agriculture, and forestry estimated that 8 percent of West Germany's forested area was damaged. Just a year later, a more thorough investigation found damage on more than 6.2 million acres—34 percent of the nation's forests. A third survey, conducted in the summer of 1984 and the latest to date, found that half the nation's trees are injured. Hardest hit are the heavily wooded states of Bavaria and Baden Württemberg, home of the fabled Black Forest.

Spruce, fir, and pine, which together represent two-thirds of West Germany's forests, are the most severely struck. The spruce and fir forests are typically managed in even-aged stands, with trees harvested between 80 and 130 years of age. Although damage first appeared on the older trees, spruce and fir of all ages are now affected. The value of the trees already lost exceeds $1.2 billion. Because a growing portion of the planned annual harvest consists of dying trees, the harvest may reach three times its normal level over the next few years. Although this may depress timber prices over the short term, future supplies are diminishing as sick and dying trees are harvested long before their time.

In a 1983 *Journal of Forestry* editorial, a German professor of forest policy, the president of the German Forestry Association, a Regensburg forester, and a former U.S. Fulbright visitor to West Germany joined together to note that "air pollution is now the problem that concerns West German foresters most. The results of 200 years of forest management seem to be extinguishable within the next 10 years. . . . Only a few people think about an all-too-possible scenario: central Europe without forests."—*S.P.*

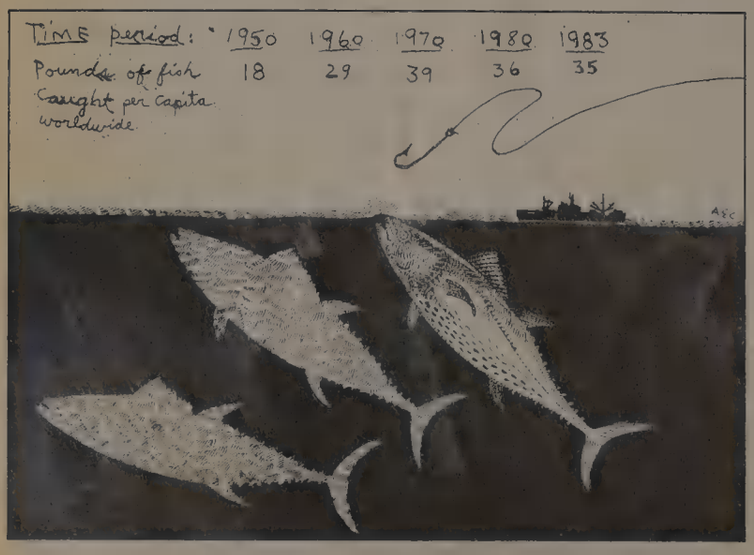
are the United States and Great Britain. While putting scrubbers on smokestacks is a necessary first step to curb acid rain in the near term, a technological fix for one pollutant cannot be an ultimate solution for a multipollutant problem. Solutions are needed that will reduce levels of all threatening pollutants. Using energy more efficiently, recycling more paper and metals, and generating more power from alternative energy sources are rarely considered in strategies to control air pollutants or acid rain, but they are perhaps the most cost-effective ways that exist.

Given the rapidity with which the forest destruction has unfolded, the relevant question is no longer whether proof of damage from air pollutants or acid rain is irrefutable but whether the forests are sufficiently threatened to warrant action. West German foresters would answer with an unequivocal yes. But the real test is whether nations that so far have been spared severe losses will muster the political will to take action to avoid them.

Sandra Postel

Overfishing was rare a generation ago. Now, in some regions it seems

to be a common occurrence. The world's fisheries occupy an important niche in the global ecosystem, the world economy, and the human diet. Their annual harvest—74 million tons in 1983—exceeds world beef production by a substantial margin. Yielding an average of thirty-five pounds per person worldwide, fisheries supply 23 percent of all animal protein consumed. More importantly, in many low-income countries, as well as in a few industrial ones, fish are the principal source of animal protein.



Between 1950 and 1970, the world fish catch more than tripled. The growing world population and rising per capita incomes boosted demand for animal protein. The extraordinary growth in the catch led to the feeling that the oceans contained infinite supplies of fish. Projections made at this time commonly indicated the catch would eventually reach 200 to 400 million tons annually. On the supply side, advances in fishing technology and the availability of cheap oil led to the development of distant-water fishing fleets that scoured the oceans in search of edible sea life.

By the early seventies, however, many signs of overfishing were appearing. Growth in the annual world fish catch slowed to less than one percent. And in per capita terms, the growth of nearly 4 percent per year during the fifties and sixties became a decline of almost one percent yearly after 1970.

The collapse of the Southeast Pacific anchovy fishery in the early seventies, caused by overfishing and ocean variability, caught the attention of many who had assumed that humanity would ultimately turn to the oceans for food. By the early eighties, eleven major oceanic fisheries—six in the Atlantic and five in the Pacific—had been depleted to the point of collapse. They range from the Peruvian anchovy, which had an estimated potential of 9 million tons, to the Alaska king crab, with a possible yield of nearly 100,000 tons. Overall, the annual harvest from oceanic fisheries has been reduced by an estimated 11 million tons because of fishery mismanagement.

Before national control was extended to 200 miles offshore, there was often no authority responsible for limiting the catch and establishing quotas for the fleets working a fishery. In some cases, overfishing resulted from a lack of information—on such things as stocks and reproductive rates—needed to manage supplies intelligently. As the biology of oceanic fisheries becomes better understood, a concern for sustainable yield is likely to dispel the myth that the oceans can provide an ever increasing supply of protein.

More than one hundred species of finfish, crustaceans, and shellfish are harvested on a commercial scale. Of this long list, some twenty-two species commonly yield 100,000 tons or more per year, and just five species—herrings, cods, jacks, redfishes, and mackerels, plus their associated relatives—account for well over half the annual catch.

The diversity of the global catch is reflected in national seafood consumption patterns. In the United States, tuna occupies a prominent position in overall seafood consumption: With tuna sandwiches and salads common fare, U.S consumption accounts for more than a third of the world tuna catch. Of the million and a half tons of squid caught yearly, most is consumed by Japan and the coun-

tries north of the Mediterranean—Spain, Portugal, and Italy. The consumption of some other abundant species is similarly concentrated in parts of the industrialized world.

Although per capita fish consumption in Third World countries is lower than in most industrial countries, fish are nonetheless a key protein source in the diet of coastal peoples. A scrap of dried fish in a rice dish can often mean the difference between a nutritionally adequate diet and one seriously deficient in protein. The worldwide decline in the per capita catch does not augur well for future nutritional improvements in developing countries.

With oceanic overfishing now commonplace, the age-old method of capturing fish by hunting and gathering is being supplemented by fish farming and ranching. In many parts of the world, fish can be raised like livestock using natural ponds or artificially flooded land. The many techniques, collectively known as aquaculture, succeed with a variety of fish and shellfish. Harvesting can be done on a small or a large scale and can often be integrated with conventional farming, using organic wastes from land to fertilize ponds and provide a food supply for fish.

Fish farming is growing at more than 7 percent each year, and cultivated fish may be the fastest-growing part of the human diet. Interest in fish farming is on the rise everywhere. China, with an estimated annual aquacultural output of just over 4 million tons, is far and away the world leader. Japan ranks second, with about a million tons—roughly one-third each of finfish, shellfish, and seaweed. Given the rapid strides in U.S. fish farming during the early eighties, a 1985 survey is likely to show the United States moving into the top ten aquacultural producers.

A growing emphasis on this approach is evident in the lending practices of such international aid agencies as the World Bank and the U.N. Food and Agriculture Organization. In the seventies, assistance that previously concentrated on investments in better boats and improved port and processing facilities shifted toward fish farming. Lenders realized that there were a limited number of offshore fisheries in which investment in additional capacity would be profitable.

Worldwide, aquaculture provides roughly one-sixth of the seafood consumed directly. Of the total finfish output of some 3.7 million tons, an estimated four-fifths is accounted for by carp, the mainstay of both the Chinese and Indian aquacultural economies. In both these countries, the aquacultural sector provides more than one-fourth of total fish consumption. In the United States, nearly all the rainbow trout, most of the catfish and crawfish, and 40 percent of the oysters are harvested from fish farms.

One of the attractions of fish farming is the high efficiency with which fish convert vegetable matter to meat. An American farmer must feed his cattle roughly 7 pounds of grain to produce a pound of beef. Pigs, by comparison, need 3.25 pounds of grain to yield a pound of pork; broilers need 2.25 pounds for a pound of chicken. Catfish, however, require only 1.7 pounds of grain to produce a pound of fish. Fish are efficient converters for two reasons. One, they are coldblooded and thus do not need to consume large amounts of energy to maintain a high and steady body temperature. And two, because they live in the water, fish do not require much energy for locomotion.

That fish farming is destined to expand seems clear; how fast it will do so is less certain. As a form of animal husbandry, it must compete with the production of beef, pork, poultry, eggs, and milk for

Salmon at Home on the Ranch

In past times, salmon apparently thrived in streams and rivers throughout the Northern Hemisphere's higher latitudes. With modernization, however, their access to many streams and rivers was often blocked by dams, as in the U.S. Pacific Northwest and in the Baltic Sea. Some rivers—such as the Thames in England, where the salmon disappeared in the nineteenth century—became so polluted that they were no longer habitable. In other instances, merciless overfishing led to the salmon's demise.

In recent years, a better understanding of the salmon's life cycle and a strong commercial demand for this tasty fish have led to the restocking of many streams. In 1763, German biologists discovered that salmon eggs could be fertilized in captivity. This knowledge, coupled with an awareness of the salmon's homing instinct, set the stage for modern ranching. Salmon hatcheries (usually publicly supported) and commercial salmon ranching are both based on the near-legendary homing instinct of this fish. Even when released in an unfamiliar setting, salmon manage to find their way back to their nursery streams some two to five years later when it's time to breed.

The only countries with extensive salmon hatcheries and annual releases of this fish are Japan, the Soviet Union, and the United States. The Japanese now release more than a billion young salmon each year in rivers and streams on the islands of Hokkaido and Honshu. After feeding in the areas south of the Bering Sea, the Aleutian Islands, and the Gulf of Alaska, the salmon return to the rivers where they were released. In the fall of 1982, the Japanese harvested 28 million salmon—one for every four Japanese. Soviet salmon ranchers are not far behind: They are expanding the number of smolts released by roughly 100 million per year, and their goal is to release 3 billion annually by the end of the century. The Soviet salmon are released in the many small streams of Sakhalin Island and the Kamchatka Peninsula. By 1990, the USSR, Japan, and the United States are expeted to release 6 billion smolts into the North Pacific.—*L.R.B.*

the use of land, water, labor, fertilizer, and feedstuffs. But in a world where pressure on resources is mounting, aquaculture should also be seen as a means of tapping currently unused resources, such as low-lying land that is not suitable for crop production.

With mounting pressures on world fisheries—oceanic and domestic—fishery analysts see seafood prices rising for the rest of the century and beyond. This may annoy Western consumers for whom salmon or Alaskan king crab is a delicacy. But it will be much more than annoying for those in the Third World for whom fish is the principal source of animal protein.

Lester R. Brown

Is human activity causing global climate changes? Until recently,

the question has rightly focused on fossil fuels and carbon dioxide (CO_2). In step with the burning of oil, coal, and natural gas, the concentration of CO_2 in the atmosphere has steadily climbed. Climatologists warn that increased CO_2 traps more of the sun's heat at the earth's surface; the implications of this "greenhouse effect" have put climate change at the center of a lively political and scientific debate.

Recently another question has emerged: Can changes in land cover, such as deforestation in the Third World, alter climate? The contribution of population growth to deforestation, overgrazing, soil erosion, and desertification in the Third World is highly visible and widely recognized. What is new is the realization that these processes may be driving climate changes in regions as diverse as the semiarid Sudan-Sahelian zone of Africa and the rain forests of the Amazon.

Natural climatic fluctuations make it difficult to separate out the possible human effects on climate. A reconstructed climatic history of the Sahel over the last 10,000 years, for example, shows extreme fluctuations, from periods of wetness to dryness. A detailed history of just the last few centuries shows that the Sahel has periodically experienced severe, prolonged drought.

Meteorologists have traditionally dismissed the notion of large-scale human-induced climate change, arguing that the natural forces driving global atmospheric circulation would override any local, human-induced alterations. Using data from other fields, such as agriculture, ecology, and hydrology, meteorologists can now piece together a plausible hypothesis that population-induced local climatic change is indeed under way in Africa, the Amazon Basin, and perhaps elsewhere as well.

The continents are watered by the oceans; therefore, any change induced by population growth must involve interfering with the mechanics of that process. Africa, for example, is watered by moisture-laden air masses from the Indian and Atlantic oceans. The Indian subcontinent receives rain from clouds moving inland from the Indian Ocean and the Bay of Bengal. The Brazilian Amazon derives almost all its water initially from the Atlantic Ocean.

Evaporation of moisture from rainfall near the coasts recharges rain clouds as they move inland. At a typical site in the central Amazon, such as one that was carefully studied near Manaus, Brazil, roughly one-fourth of the rainfall evaporates directly, and nearly one-half reenters the atmosphere in the form of transpiration from plants. Together, direct evaporation and transpiration return three-fourths of the rainfall to the atmosphere, leaving one-fourth as runoff that makes its way back to the Atlantic. Such high levels of cloud recharge have led ecologists to refer to tropical rain forests as "rain machines."

When land is deforested, however, this ratio is roughly reversed, with a quarter of the rainfall being returned to the atmosphere and three-quarters running off quickly. Rainfall in the region is accordingly reduced, as the atmosphere holds less returned moisture that can become rain later in the cycle. The more distant from the coast, the more an area depends on evaporation for the recharge of rain clouds. Even in semiarid regions, an estimated one-third to two-thirds of all rainfall comes from soil moisture evaporation.

Water first enters the Amazon area in moisture-laden air masses from the Atlantic Ocean. As these progress westward, they continually discharge moisture in the form of rain and are recharged by evaporation and transpiration. On the average, water in the Amazon that does not return to the ocean completes the cycle every 5.5 days. During this process some of the water works its way out of the evaporative cycle as runoff and begins the long trip back to the Atlantic. Moisture left in the air when it reaches the Andes moves southward into central Brazil and the Chaco/Paraguay river regions, where it becomes part of the rainfall cycle in major farming areas.

As the Amazon rain forest is converted to cropland or grassland or is cleared by logging, the share of rainfall that runs off increases. The proportion that returns to the atmosphere through evaporation falls, reducing the total amount of water in the area's hydrological cycle. The net effect is lower average rainfall, particularly in the west. Less rain in

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Too often fear delays treatment. The best way to overcome fear is to get all the facts. More often than not, your fear that you have cancer will prove to be wrong. But it is still absolutely essential that you get a medical examination and that your doctor (not you, nor your family, nor your friends) make a diagnosis.

Fear that someone in your family has cancer should also be promptly addressed. Here again, seek the advice of your physician. There are also many qualified professionals and special organizations that provide information on cancer in virtually every major community in the United States.

Remember, knowledge is the best cure for UNFOUNDED fears.

Hope is the key to the future.
Hope is what the latest facts and figures on cancer are all about.
Hope resides in early diagnosis.
Hope resides in early treatment.
Hope resides in current research.

We now know that cancer can be diagnosed and treated with an array of new technology and knowledge. You are not alone in preventing or treating cancer. You need and have a support system. We call it...

Partners in Healthcare:

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Only you can take the first step. And at the first warning sign—a lump, unusual bleeding from any part of the body, a sore that does not heal, an obvious change in a wart or mole, a nagging cough or hoarseness, a change in bowel habits—DO NOT WAIT. CONSULT YOUR PHYSICIAN AT ONCE.

Your doctor interprets the warning signs, orders your tests and makes the diagnosis.
The chances are that your physician will find something other than cancer. But it is essential that, whatever tests are needed, they be done quickly for an early diagnosis.

All those who discover, develop and distribute medicines complete the partnership.
Pharmaceutical companies in the past few years have developed many good drugs for cancers. We at Pfizer are fulfilling our role as one of your partners in healthcare by mobilizing our doctors, chemists, technicians, a huge range of facilities and modern instrumentation to do our share in the search for the cause and the ultimate cure of cancer and other diseases.

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On the BMW, as on the aircraft, electronic sensors measure the rotational speed of the wheels, feeding this data to a computer. (The computer is well fed; we use four sensors as against a competitor's three.)

Then, operating on the computer's command, a hydraulic control unit applies braking pressure as it should be applied: in the rapid pumping movements that prevent the brakes from locking.

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Should any wheel begin to lock, the computer instantaneously reduces braking pressure until control is regained. A vital factor in panic stops, where both wheels and driver freeze, placing the car at the mercy of its own momentum. ABS permits you to steer and stop at the same time.

ABS is new, and standard, on the BMW 735i, 635CSi and 535i. But in the ways that matter most, it isn't new at all, having proven itself not just on airborne vehicles, but their landborne equivalents: BMW race cars dating back over a decade.

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the Amazon would almost certainly reduce the amount that reaches the agriculturally important Paraguayan Chaco and central Brazilian plateau.

In Africa, northeastern Brazil, northwestern India, and northwestern China—where rapidly growing populations are generating wholesale shifts in land use—deserts are expanding. Recently the United Nations Environment Programme undertook a survey of desertification in countries in the Sudan-Sahelian region of Africa. The fourteen most populous countries in this group have a combined population of 230 million people, 43 percent of the African total. The survey focused on five manifestations of desertification—sand dune encroachment, rangeland deterioration, forest depletion, the deterioration of irrigation systems, and problems in rainfed agriculture.

Not one of the seventy indicators—five for each of the fourteen countries—showed any improvement. According to thirteen of the seventy indicators, there was no significant change during the seven years under review. Half the total measurements showed moderate deterioration. The remaining twenty-one showed serious deterioration. The three categories showing the most consistent deterioration were rangelands, forests, and rainfed agriculture. Field observers confirm the survey findings, describing them as somber but realistic.

Perhaps because of the Sahelian drought of the early seventies and the continent-wide drought experienced in Africa in 1983 and 1984, more attention has been focused on changing land-use patterns caused by population pressure and the possible effects on local climate. In addition to the evidence from agriculture and meteorology, and the desertification trends, hydrological data also suggest that Africa is "drying out." In an analysis measuring changes in river flows, J. Sircoulon observes that "the Senegal, Niger, and Chari rivers, coming from wetter regions to the south . . . have undergone a severe decrease of runoff during the last 15 years. . . . Lake Chad has shown a systematic decrease of level since 1963. At that time the lake's surface covered 23,500 square kilometers, and the volume of stored water was 105 billion cubic meters. In 1973 the surface had been divided by three and the volume by four. Since this date, the lake has been cut into two parts. The northern part dries up every year, with only a small inflow through the 'Grande Barrière.' "

Most meteorologists have been reluctant to attribute significant shifts in climate to human changes in land use. Although the evidence that can now be assembled from several fields of study is not yet conclusive, it is persuasive. Reflecting on this, Canadian meteorologist Kenneth Hare, in an analysis of desertification in Africa, has concluded that "we seem to have arrived at a critical moment in the history of mankind's relation to climate. For the first time we may be on the threshold of man-induced climatic change."

Knowing what we do about the extent of deforestation, overgrazing, and soil degradation during the past generation and about the way the hydrological cycle works, we should not be surprised by changing climate. More significantly, population growth may be driving that change in directions that will not benefit the people affected, reducing rainfall in areas where rain is needed for crop production and livestock grazing. And expanding deserts, in turn, are shrinking the land area available for growing food, grazing livestock, and producing firewood. The effectiveness—or ineffectiveness—of family planning programs may be shaping the climate of some countries for decades and possibly for centuries to come.

Lester R. Brown

The failure to eliminate human hunger weighs heavily on the collective

conscience, dimming the numerous remarkable achievements of the late twentieth century. From about 1950 to 1973, world food production surged ahead, outstripping population growth and holding out the hope that hunger could be banished. In the last decade, however, growth in production has slowed, raising doubts about the long-term food

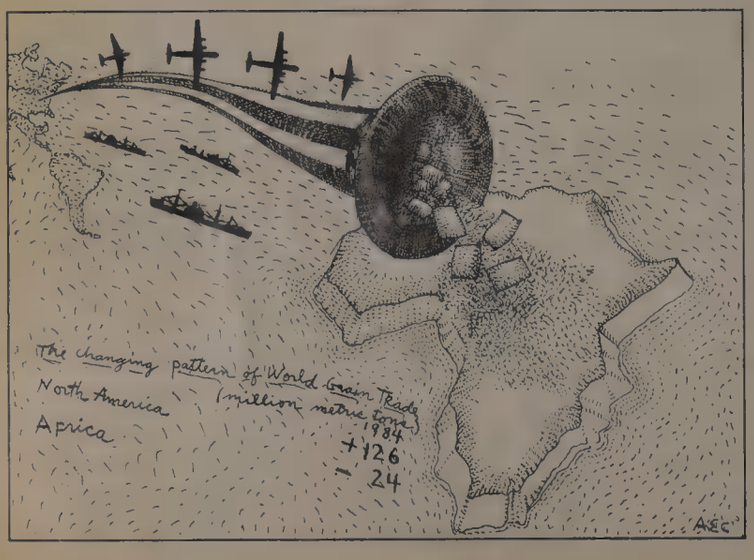
prospect. Despite advances in technology, the effort to reduce hunger is at a standstill.

The shifting contours of the world food economy are dominated by two major developments. One is the leveling off of per capita food production since 1973, following a quarter-century of steady gains. The other, obscured by this global trend, is the growing food gap between country and country, continent and continent. In some regions, per capita food production is surging ahead; in others it is falling steadily.

From 1950 to 1973, the year of the first oil price hike, world grain output expanded more than 3 percent annually, boosting per capita output by some 30 percent. Since then it has averaged only 2 percent yearly, barely keeping pace with population growth. Tightening supplies of energy, land, and water are now shaping the world food prospect.

From the beginning of agriculture until roughly mid-century, the expansion of the world's cropland area more or less matched the growth in world population. The supply of food increased from year to year largely because the total cultivated area was expanding. But improvements in productivity per acre came slowly or not at all. At mid-century, this began to change. Since then most of the growth has come from boosting land productivity. Growth in the cropland area has continued to slow, coming to a standstill in some countries. Between 1980 and 2000 the world cropland base is projected to expand by only 4 percent, while the world's population is projected to expand by some 40 percent.

In recent decades, much cropland has been lost to industrialization and to urbanization, the latter being one of the most globally pervasive demographic trends of this century. How much cropland is disappearing under cities is not known, but various surveys and data from individual countries provide some indication. For example, U.S. Department of Agriculture surveys in 1967 and 1975 indicated that some 6.2 million acres of prime U.S. cropland were converted to urban uses during the eight-year period. A study of urban encroachment on agricultural land in Europe (grasslands as well as croplands) from 1960 to 1970 found that West Germany was losing one percent of its agricultural land every four years. For France and the United Kingdom, the comparable figure was nearly 2 percent for the decade.



While attention has focused on urban encroachment, cropland is also being lost to village expansion. Unfortunately, little research has been conducted on this loss. Using data gathered during several decades in his native Bangladesh, Akef Quazi concludes that growth of the area occupied by a village and growth in the number of families are closely related. One reason for this correlation is that homes are "made up of locally available materials, such as bamboo, thatch, and corrugated iron sheets and, as such, are never strong enough to hold an upper story." Quazi reports that "every new village homestead is being built on cropland." Undoubtedly there are occasional exceptions, but Quazi's point is a sound one, for Bengali villages are usually surrounded by the rice fields on which they depend.

Industrialization also consumes large areas of land. Since the mid-fifties factory construction has been one of the main causes of cropland shrinkage in western Europe and Japan. More recently, industrial development has begun to claim land in developing countries as well. Land-hungry China has been especially affected. Factories must be built in the east and south, where most Chinese live, which is also where most farmland is located. Dwight Perkins, a scholar on China, notes that the 10 percent annual industrial growth steadily consumes cropland. He believes planners are aware of this but that "there is no way around the fact that good farmland (flat, located near transport, etc.) often makes an excellent factory site."

Even more than the scarcity of fertile land, lack of water resources may constrain growth in world food output. In countries as widely separated as Mexico and Pakistan, scarcity of fresh water prevents the spread of high-yielding wheats. In the Soviet Union, water shortages are frustrating efforts to expand feed-grain production for that country's swelling livestock herds. As new irrigation options are exhausted, the link between water and bread becomes increasingly obvious.

Some 15 percent of the world's cropland is irrigated, up from 11 percent in the early sixties. Irrigation was once concentrated in the Middle East, where it first developed, but as of 1980, 46 percent of the world's irrigated lands were located in Asia.

The effectiveness of irrigation is greatly enhanced by the use of chemical fertilizer. As new areas of agricultural settlement became scarce after World War II and population growth speeded up, demand for fertilizer began to climb. In 1950 the

China: Land for the Living, Not the Dead

As the world population moves steadily toward five billion, new manifestations of population pressure are surfacing. In China, where the dead are buried under mounds that are often located on good farmland, authorities are now trying to conserve land by encouraging cremation instead of traditional interment.

A study of this burial practice in the immediate vicinity of Beijing reported that from 1949 until 1964 burial mounds claimed 526 acres of fertile cropland. Multiplied thousands of times over for the country as a whole, this loss is of great concern to Chinese political leaders. Accordingly, the government has launched a campaign to encourage cremation.

Although persuading people to change centuries-old traditions is difficult, Zhang Yizhi, an official in the ministry of civil affairs, believes that the shift to the family responsibility system will ease this transition: "If the peasants want to become more prosperous, they will not be able to let the dead occupy the limited land that is available for farming." Veneration of ancestors continues, but in this crowded country, the living compete with the dead for land.—*L.R.B.*

world used less than 14 million tons of chemical fertilizer. Within a decade that figure had doubled; in the next decade it doubled again. By 1984 world consumption of fertilizer totaled 121 million tons, a ninefold increase in thirty-four years. Eliminating its use today would probably cut world food production by at least a third. At a minimum, a billion and a half people are now fed with the additional food produced with chemical fertilizer.

Since mid-century the increase in world fertilizer use has been driven by population growth and by the expanding appetite for animal protein. As the stork outruns the plow, the role of fertilizer is magnified. The reduction in world cropland area per person since 1950 has been offset by raising per capita fertilizer use fivefold between 1950 and 1980. In simple terms, more people now means less cropland per person, requiring more fertilizer to satisfy a given dietary level.

In recent years the growth in world fertilizer use has slowed markedly. After expanding by 7.5 percent annually from 1950 through 1973, growth dropped to 5.6 percent per year during 1973 to 1979 and to 2.5 percent per year since the 1979 oil price increase. This slowdown is not due to any single influence but rather to several, many of them associated with diminishing returns and, directly or indirectly, rising oil prices.

During the last thirty years, the pattern of world food trade has been reshaped by widely varying population growth rates and levels of agricultural management among the major regions. As recently as the late thirties, Western Europe was the only grain-deficit region and Latin America was the world's leading grain supplier, exporting some 9 million tons per year. North America and Eastern Europe (including the Soviet Union) each exported 5 million tons of grain annually. Even Asia and Africa had modest exportable surpluses.

By 1950, the shift from regional grain surpluses to deficits was well under way as Eastern Europe, Latin America, Asia, and Africa all moved to the deficit side of the food ledger. With these shifts, the outlines of a new world grain-trade pattern began to emerge. North American agricultural growth gained momentum after World War II, and in 1984 United States and Canadian grain export climbed to 126 million tons. Feed grains—principally corn, sorghum, and barley—have made up an ever larger share of the total. Today, North America is not only the world's breadbasket, but its feed bag as well.

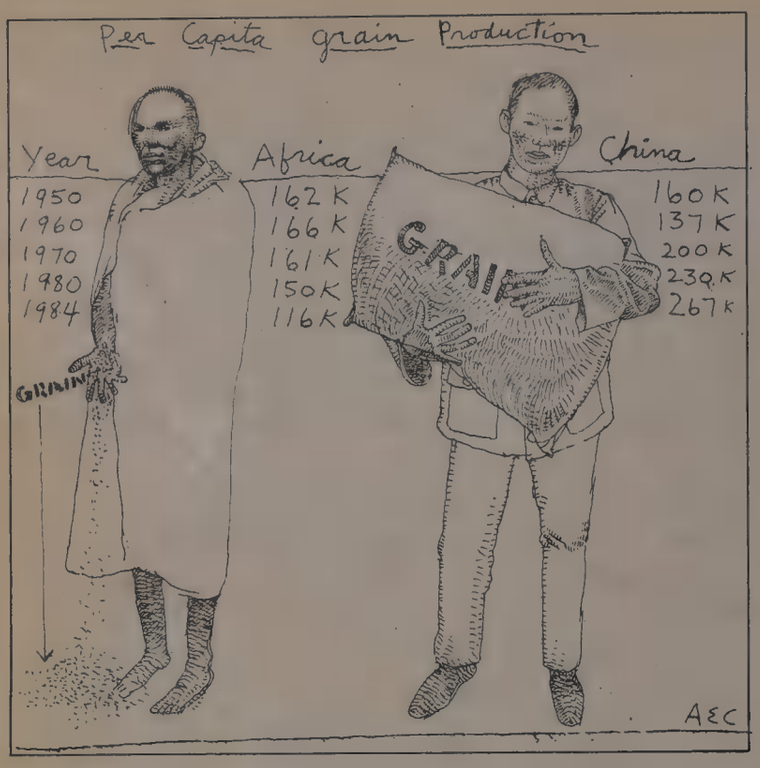
As the North American share of world grain exports has increased, it has surpassed the Middle Eastern share of oil exports and made the world more dependent on one region for its food than ever before. This overwhelming dependence on one region, and on one country in particular, brings with it an assortment of risks. To begin with, both the United States and Canada are affected by the same climatic cycles. A poor harvest in one is often associated with a poor harvest in the other. When reserves are low, even a modest fluctuation in the region's exportable grain surplus can send price tremors through the world food economy.

To restore the upward trend in per capita food production for the world as a whole, either harvests must grow or population growth must slow. Given the emerging constraints on cropland, water, and energy, it will be difficult to reestablish and maintain a 3 percent rate of growth in food production. The hope of eliminating hunger in the Third World thus rests more heavily than ever on population policies and family-planning programs.

Lester R. Brown

The world's population picture at mid-decade is one of stark contrasts.

Variations in fertility among countries have never been wider. Some populations change little from year to year or decline slightly; others are experiencing the fastest growth ever recorded. The popu-



lations of West Germany and Hungary are slowly getting smaller, for example, while those of Kenya and Syria are doubling in less than twenty years.

These disparities are placing great stress on the international economic system and on national political structures. Runaway population growth is indirectly fueling the debt crisis by increasing the need for imported food and other basic commodities. World Bank president A.W. Clausen observes that "population growth does not provide the drama of financial crisis or political upheaval but its significance for shaping the world of our children and grandchildren is at least as great."

Demographers describe the relationship between population growth and levels of development in terms of a three-staged process called "the demographic transition." In the first stage, which characterizes traditional societies, both birth and death rates are high. Societies have existed under these circumstances for thousands of years without any appreciable change in population size. Births and deaths remain largely in balance.

In the second stage of the demographic transition, living conditions get better as public health improves, vaccines become available, and food production expands. In this stage, births remain high but deaths fall. The result is the rapid population growth of close to 3 percent yearly that characterizes many Third World countries.

The third stage sees living conditions improve further, birth control become widely available and used, and births decline to again roughly offset deaths. The United Kingdom, West Germany, and Hungary are among the dozen or so countries that have completed the demographic transition, reestablishing an equilibrium between births and deaths.

Societies can remain in either the first or the final stage of the demographic transition indefinitely. This is not true, however, of the middle phase. Many developing countries have been in the middle stage since roughly mid-century. Those now in the fourth decade of 3 percent annual population growth are en route to a twentyfold expansion in a century. Unfortunately, it is difficult to imagine any country, even one that was sparsely populated at mid-century, surviving such an increase with its biological support systems and social institutions intact.

The evidence of recent years suggests that countries stuck in the second stage for more than a few decades experience mounting population pressures—pressures that eventually destroy forests, grasslands, and croplands. As these resources deteriorate, mortality rates begin to rise to reestablish a balance between births and deaths. Countries that do not make it to the demographic equilibrium of the third stage will eventually return to the demographic equilibrium of the first. Nature provides no long-term alternative.

Many of the countries that have broken out of the second stage of the demographic transition have done so with the aid of cheap energy and relatively favorable population–land ratios. Others are finding it increasingly difficult to reach the point where gains in per capita income and the use of birth control begin to reinforce each other with substantial gains in living standards.

Whether a country can move from the middle to the final stage of the demographic transition is perhaps best judged by looking at trends in per capita food production. China and Africa, with populations of just over one billion and 531 million respectively, illustrate contrasting prospects. China appears to be breaking out; Africa, having failed to do so, appears to be breaking down.

Following almost a quarter century of stagnation, per capita food production in China has climbed at an encouraging rate during the past decade. The rate of population growth has been halved since the early seventies, dropping to just over one percent per year. Grain production per capita in the mid-eighties is up by one-fourth from the early seventies. Even though China has serious environmental problems in agriculture, including soil erosion, and although its cropland base is shrinking, there is a good prospect that its living standards will continue to improve through the end of the century.

Africa, in contrast, shows no movement toward the third stage of the demographic transition. And time is running out. Population growth for the continent as a whole is close to 3 percent. The share of the population using birth control is minuscule. Grain production per capita in Africa turned downward after reaching a postwar high of nearly 400

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pounds per year in 1967. During the mid-eighties, grain production per person is nearly one-fifth below the level of the late sixties. Several countries are reporting deaths due to starvation.

In a recent report, the World Bank expressed concern about rising death rates in several African countries. Bank officials feel that in the absence of a major initiative, a number of countries will experience a disintegration of social institutions and will revert to "bush" economies. Without a sharply expanded effort in both family planning and farming, much of the continent may drop back into the first stage of the demographic transition.

Other major areas of the world have also remained in the second stage for a dangerously long period, among them the Andean countries in Latin America (Bolivia, Chile, Ecuador, and Peru), northeastern Brazil, and the Indian subcontinent. Under the circumstances now unfolding, there is growing uncertainty about how many countries in the middle of the demographic transition will be able to break out. By the end of the century, the world may be divided into two groups: countries that have progressed into the final stage and those that have fallen back to the first stage. There are unlikely to be many countries left in the middle. The demographic transition in each nation will have been largely completed or aborted.

Countries with rapid population growth that wait too long before applying the brakes may find themselves in trouble. The first country to recognize this was China. In the late seventies, the Chinese undertook several alternative projections of population growth and resource demands. Even assuming that each couple would have just two children, the population would clearly continue to grow, because of the youthful age structure, by another 300 to 400 million people. Leaders in Beijing recognized that such an increase in population would further reduce already limited per capita supplies of cropland, fresh water, and energy, thus jeopardizing the hard-earned gains of the past generation. Rather than risk a fall in living standards, they decided to launch a one-child family program.

Like China, other Third World countries appear to be waiting too long before tackling their population problems. China is unique in terms of population size, but it shares with every country the relationship between population and local life-support systems. The principal difference between China and other rapidly growing countries such as Bangladesh, India, Ethiopia, Nigeria, and Mexico may be that the Chinese have had the foresight to make projections of their population and resources and the courage to translate the findings into policy.

In one Third World country after another, the

High- and Low-tech Birth Control

The world faces two family planning gaps: one between the demand for contraceptives and their availability, and another between societies' need to reduce population growth quickly and couples' willingness to cooperate. Efforts to close the first gap have led to a wide array of contraceptive practices.

Worldwide, sterilization protects more couples from unwanted pregnancy than any other practice, largely because of its prevalence in three populous countries—China, India, and the United States. Oral contraceptives (the pill) rank second, partly because they are extensively used in both industrial and developing countries.

Patterns of contraceptive use vary widely among countries and do not necessarily correspond to levels of development. The pill, for example, completely dominates Egypt's family planning program: Seventeen of every twenty couples using contraception rely on this method. And in Indonesia nearly three out of five couples practicing contraception take the pill.

Ironically, this modern contraceptive is prevalent in some key developing countries at the same time that traditional techniques are still extensively used in some industrial nations. In France, for example, fully a third of the couples practicing contraception still use traditional methods, such as withdrawal. In Eastern Europe, these older techniques also dominate the effort to limit family size because modern contraceptives are not consistently available; as a result, the number of abortions in these countries sometimes exceeds the number of live births.

India is unique in its overwhelming dependence on sterilization, both male and female, largely because of vigorous government promotion and the failure, until recently, to provide other methods, such as oral contraceptives. Reportedly, five of every six couples protected by contraception rely on sterilization, with most of the remainder relying on the condom and IUD.

Women in China, in contrast, depend heavily on the IUD—half the 118 million married women of reproductive age who are using contraception choose this method. Sterilization is the second most popular method in China, with the pill a distant third.

In the United States, sterilization has overtaken the pill as the most widely used contraceptive method, chosen by one-quarter of the couples who practice birth control. The pill accounts for more than one-fifth. Most of the remaining couples choose diaphragms or IUDs. The pattern in the United Kingdom is strikingly similar, largely because of cultural similarities.

Cultural influences shape contraceptive use in unexpected ways. In Indonesia, for instance, the IUD is popular on Bali, which is populated by Hindus. But on Java, with its predominantly Muslim population, it is far less prevalent. Apparently Balinese women are accustomed to male childbirth attendants, whereas Javanese women rely on midwives and are thus reluctant to have a doctor, usually a man, insert an IUD.

The availability of contraceptives alone will do nothing to narrow the troubling gap between the family size desired by couples in some regions and the number of children their societies can support. In Africa, where living standards are already falling, failure to encourage smaller families will surely cancel the gains won by providing contraception.—*L.R.B.*

pressure on local life-support systems is becoming intolerable, as can be seen in their dwindling forests, eroding soils, and falling water tables. If other governments take a serious look at future population–resource balances, they may reach the same conclusion the Chinese did. And they may be forced to choose between a one-child family program and falling living standards. Given the unprecedented numbers of young people who will reach reproductive age within the next two decades, a generation of one-child families may be the key to restoring a sustained improvement in living standards. Success in striving for an average of one child per family will bring its own problems, including a severe distortion of age-group distribution, but it may be the price many societies must pay for neglecting population policy for too long.

Lester R. Brown

Opportunities to save energy are many and impressive. A single

decision in the United States—to raise automobile fuel economy to forty miles per gallon—or in the Soviet Union—to produce steel as efficiently as Japan does—would save as much energy as Brazil now consumes. Such opportunities can be found again and again in each of the consuming sectors.

But are such decisions in the offing? A survey of forecasters shows a consensus that by the year 2025 worldwide commercial energy demand will increase from about 135 million barrels of oil equivalent per day to 300 million barrels per day. If this scenario were to unfold, the oil output of two new Saudi Arabias would be needed. In addition, the coal production of the world would more than triple. Four and one-half as many rivers would have to be impounded behind hydroelectric dams. A total of 365 large nuclear power plants would be added.

Among the consequences of using so much energy would be greater risk of acid rain, changes in climate induced by carbon dioxide, species extinctions, water degradation, and proliferation of nuclear weapons. According to the forecast, acid-rain-causing sulfur emissions would triple in forty years. And in the next century, the atmospheric concentration of carbon dioxide (compared to preindustrial levels) would double and cause an atmospheric temperature increase large enough to flood coastal cities and shift rainfall patterns all over the globe.

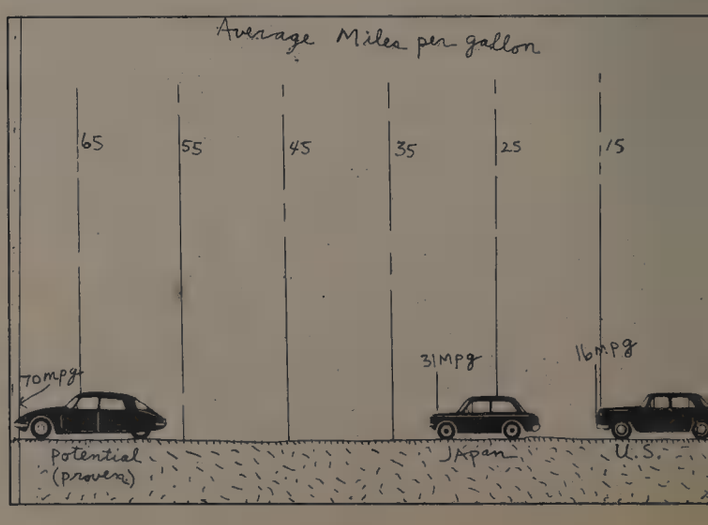
The economic prospect of a future with high energy demands is similarly unappealing. Much of the Third World's debt has been incurred to finance energy imports. Foreign payments for oil consume the largest share of total export earnings for many countries, including half of those of Japan and Brazil. Expensive hydroelectric and nuclear energy systems have added to this reservoir of debt.

Industrial processes consume more of the world's commercial energy than either transportation or housing. Industry, at the same time, has provided the largest efficiency gains of any energy-using sector since World War II, with an annual rate of improvement of more than one percent even as energy prices declined. This rate tripled in Western nations after the energy price increases of the seventies. Despite the gains, however, there is still an enormous potential for cutting energy costs in existing plants, and builders of new production facilities can choose far more efficient equipment and processes.

Japan's steel industry, for example, is a leader in efficiency. The Japanese use 30 percent less energy per ton than the world average, and only half as much as the Chinese and Indians. The Soviet Union, the world's largest steel maker, uses 65 percent more energy per ton than Japan. The Japanese reduced energy use by retrofitting mills that produce iron from ore. But even the Japanese steel industry could be 20 percent more energy efficient, especially if it relied more on recycling, which saves up to two-thirds of the energy used to produce steel from ore.

Some measures, such as improving electric motors, are available in industries as diverse as paper, chemicals, and cement making. Electric motors consume more than 80 percent of all electric energy used in U.S. industry and a remarkable 40 percent of all electricity used in Brazil. If Brazil invested in more efficient motors and motor speed controls, it could save 10,000 megawatts by the year 2000, or more than 17 percent of its projected new demand for generating capacity.

The macroeconomic models in vogue today implicitly assume that conservation will not work well. Most assume that the United States, for example, will not reach the current Japanese level of effi-



Six Ounces of Gasoline in a Soda Can

Throwing away an aluminum beverage container wastes as much energy as filling the same can half full of gasoline and pouring it out on the ground. Failing to recycle a daily edition of the *New York Times* or the *Washington Post* wastes just as much. Recycling, fortunately, yields back much of the energy invested in materials. It saves 90 percent of the energy required to make aluminum from bauxite, more than half that needed to make steel from iron ore, and a third of the energy needed to make paper from wood.

Because the production and consumption of energy in wood, aluminum, and steel processing create severe environmental problems, recycling also protects the environment. It reduces air pollution, strip mining of the coal used by power plants, oil spills, and solid waste. Yet despite recycling's advantages, the world has fallen far short of achieving its potential. Only about one-fourth of the paper, aluminum, iron, and steel used in the world is recovered. This rate could be doubled or tripled for each material.

Japan, the Netherlands, and South Korea lead in waste paper recovery and use. Japan collects almost half of the paper it consumes. The Netherlands collects about 45 percent. South Korea makes 40 percent of its paper from waste paper imported mainly from the United States, which collects only a quarter of the large amount of paper it uses.

In 1970 the United States ranked last in aluminum recycling. But producing aluminum from ore is very energy intensive, and the energy price increases of the seventies provided a powerful incentive to recycle. As a result, the rate of recycling aluminum beverage containers, for example, has increased from 15 to more than 50 percent. One innovation that helped bring this improvement is the "reverse vending machine." The machine accepts aluminum cans, rejects ferrous cans, glass, or other unwanted objects, weighs the aluminum deposited, and dispenses money or coupons in payment.

The nine states that now have mandatory beverage container deposit laws, however, recycle about 90 percent of their beverage containers. Still, each year the United States throws away more aluminum in beverage containers than is made on the entire continent of Africa.

In Japan and the Netherlands, recycling of metals, paper, and glass works well because consumers sort their waste into separate containers for collection. Mandatory source separation has worked well in Islip, New York, where 50 percent of the population has complied willingly. New laws in Minnesota, Oregon, Michigan, and in Canada are now giving citizens the opportunity to recycle.

Many people still lack basic material amenities—metal for water pipes, wood for housing—and the world population is still growing. Thus, to improve or even maintain living standards will require much higher energy efficiency in materials production if unacceptable economic as well as environmental costs are to be avoided. As Jean-Jacques Rousseau wrote in 1754, "It is obviously contrary to the law of nature . . . for a handful of people to wallow in luxury while the starving multitude lacks the necessities of life." Recycling can help provide necessities.—*W.U.C.*

ciency in steel for thirty-five years. They assume that the Soviet Union, China, and India will not match today's performance by the Japanese until after the year 2050.

Although the transportation sector uses less energy than industry, it uses oil almost exclusively. Automobile fuel economy, mass transit, and efficient freight hauling thus offer the largest oil savings. Private cars consume about 17 percent of the oil used each year. The United States, for example, uses 10 percent of the world's oil output as gasoline for motorcars and light trucks.

The world average auto fuel economy is about twenty-one miles per gallon, while Japan has a level of thirty-one and the United States only about sixteen. If by 2000, American cars—the world's least efficient fleet—were as efficient as the Japanese cars, world oil use would be 5 percent less than today. Doubling auto fuel efficiency worldwide would allow savings of about 8 percent of world oil output. Achieving this should cost less than $20 per barrel saved. The alternative, producing gasoline or alcohol fuel, will cost $40 to $60 per barrel.

There are many ways to achieve high fuel economy levels. Reducing auto weight, for example, can save 25 percent of the energy used in the typical American car. Designing more efficient engines can yield another 20 percent improvement. Installation of efficient, continuously variable transmissions can save 20 percent. Simply installing the most efficient tire available on the market today would improve the fuel economy of most cars by one to three miles per gallon. Several automakers have produced prototype cars that travel seventy to ninety miles per gallon.

Mass transit is inherently more efficient than the private car. In West Germany, for example, railroads use only one-fourth as much energy as cars to move people an equal distance. The autobus is comparable in efficiency. No mode of passenger transportation, however, is both more flexible and more efficient than the van pool. Jitneys—vans or other small vehicles operated like taxis along fixed routes—provide efficient, inexpensive mass transit in more than a dozen cities in developing countries around the world.

In industrial nations, energy use in buildings can be cut in half. Appliances for space heating, water heating, air conditioning, and refrigeration require three-fourths of the energy used in U.S. buildings, with 42 percent going for space heat alone. Typical gas furnaces are about 70 percent efficient, but new gas-fired systems are up to 94 percent efficient. Unfortunately, consumers usually choose the less efficient units. Furnace size and fuel use can be reduced with more insulation, and Swedish homes, on average, have twice the insulation values of homes in Minnesota.

Japanese refrigerators, even adjusted for smaller size, are twice as efficient as U.S. refrigerators. They do not sacrifice frost-free features or other conveniences to attain efficiency.

Half the electricity used in the United States for lighting could be saved by substituting more efficient bulbs and fixtures. This savings would total 420 billion kilowatt-hours per year—40 percent more electricity than the entire annual hydroelectric or nuclear power output of the United States.

Household energy use in the developing world—mainly firewood for cooking—is also very inefficient. The widening circle of firewood collection, moreover, adds to the deforestation and soil erosion caused principally by lumbering, agriculture, and drought. More efficient stoves would cut fuelwood use by 25 to 50 percent. The key to saving firewood and dung is the dissemination of low-cost, prefabricated stoves that are both durable and simple to use and service.

By making use of the available conservation technology, energy growth can be cut in half by the year 2025. Oil production equal to the current output of Saudi Arabia and Venezuela would be saved. Coal amounting to 40 percent more than the entire world uses today would be saved. The net economic savings in energy use would total more than $1 trillion per year in 2025.

Acid-rain-forming sulfur emissions, instead of tripling, would only increase about one-third. Emission-control technologies would still be required, but their cost would be drastically reduced. Conservation would also reduce carbon dioxide emissions sufficiently to provide time to find substitutes for fossil fuels.

To achieve these savings, by the year 2000 the world average energy efficiency in steel making, for example, will have to be equal to that of the Japanese today, and equal to the best currently available technology by 2025. Similar targets must be met for aluminum, paper, cement, and chemicals manufacture. Automobiles would have to average thirty-one miles per gallon by the end of the century and forty-five miles per gallon by 2025. Efficiency gains would permit the same amount of residential energy used today to provide twice as much space heat, hot water, air conditioning, and refrigeration worldwide by 2025.

All governments must take major policy initiatives to achieve this conservation potential. The crucial policies include market pricing of energy, elimination of subsidies for energy use, implementation of regulations that overcome market failures, provision of consumer information, research and development, and visible encouragement of conservation by leaders at all levels.

The most efficient nations are those that not only have accepted the reality of market prices but also bill energy consumers for the environmental and social costs of energy. The tax on gasoline exceeds the price, for example, in Argentina, Belgium, Colombia, the Netherlands, South Korea, and the United Kingdom. In South Korea, the tax exceeds $2 per gallon.

Market pricing, even coupled with energy taxes, will not entirely solve the problem. The classic example of how markets sometimes fail is the appliance bought by a landlord who does not pay the energy bill for operating it. The landlord has every incentive to buy the least costly furnace or water heater, not to pay more for one that will save energy costs. The tenant who will pay the energy bill has no say in the choice of appliance. The obvious targets for minimum performance standards are automobiles, furnaces, water heaters, air conditioners, refrigerators, and heat pumps.

Policy makers are thus presented with the task of making energy policy on numerous fronts. Unless falling oil prices are stabilized, the current situation could start a new cycle of energy consumption growth and rapid price increases.

William U. Chandler

Replacing fossil fuels with renewable energy that is environmentall

benign is one of the keys to creating a sustainable society. From the time the first coal mines were opened and the first oil wells were drilled, the world has been slowly but inexorably running out of fossil fuels. For more than a decade, scientists and entrepreneurs worldwide have been working to improve renewable energy technologies and bring them into widespread use. Much of the progress in the past decade was stimulated by government-sponsored research and development. Although modest compared with government support of the nuclear industry, the achievements are impressive and helped pave the way for future progress.

The challenge in the years ahead is to maintain the momentum despite falling oil prices, which threaten to lure policy makers back to the sort of complacency that helped produce the energy crises of the seventies. Amid falling oil prices and laissez-faire government energy policies in some countries, renewable energy development might be expected to lag badly. Instead, worldwide reliance on renewable energy sources has grown more than 10 percent per year since the late seventies.

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mainly in the form of hydropower and wood fuel. That figure has risen only slightly since 1973, but more rapid growth is likely in the years ahead. The list of important renewable energy sources will grow to a half dozen or more and will include wind power, solar heat, geothermal energy, waste products, alcohol fuels, and photovoltaic cells. Although none of these will solve the world's energy problems by themselves, collectively they can meet the modest additional energy needs of a more energy efficient world economy.

Wood fuel is the world's most heavily used renewable energy source, and the examples of India and the United States highlight a striking dichotomy. Both now burn approximately equal amounts of fuelwood, but in the United States the 130 million tons of fuelwood used annually represents only 4 percent of energy use, whereas in India it supplies one-fourth the country's energy. Overused in the developing world, fuelwood is a necessity that is in ever shorter supply. Largely supplanted by other energy sources a century ago, wood is now underused in the industrial world.

More than 100 million people in the Third World cannot get enough wood to cook their food, and more than a billion are meeting fuel needs only by overcutting and depleting their wood resources. Much of Africa faces a daunting energy crisis as well as a food crisis. Many forests have been destroyed and others dwindle yearly under the pressure of growing populations. Efforts to accelerate the planting of forests, introduce more efficient cookstoves, and find alternative fuels have been under way for almost a decade but show limited success so far.

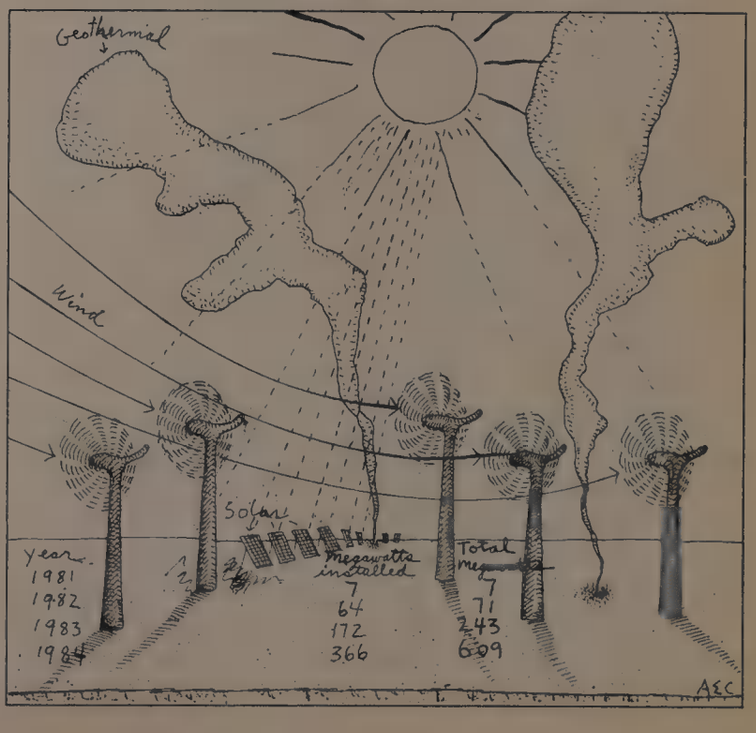
Leading the industrial world's return to wood fuel is Sweden, which plans to burn fifteen times more fuelwood, wood chips, and forest residues by the year 2000, enough to supply 12 percent of the country's energy. Wood will be used to run factories, to provide district heat to small towns, and to produce methanol for automobiles. In the United States, wood energy use has increased by more than 50 percent since 1973, thanks to homeowners who installed wood stoves to reduce their soaring heating bills. In 1981 alone, two million wood stoves were purchased, and American homes collectively burned 48 million tons of wood—equal in heating value to 100 million barrels of oil. In rural areas of New England and the West, wood is now the main heating fuel.

Lately, wood burning by U.S. industry and utilities has also been increasing. They now use nearly twice as much wood energy as households do. The forest products industry now derives 60 percent of its energy from wood, and other industries are also beginning to install boilers that can run on wood pellets, chips, bark, or pulp. Procter and Gamble spent $30 million to convert its large Staten Island, New York, plant from oil to wood in 1983. In Vermont, the Burlington Electric Company completed a 62-megawatt, $76 million wood-fired power plant, the world's largest, in 1984. There are an estimated twenty-six wood-fired power plants planned or under construction nationwide.

Hydropower is the second largest renewable energy source, providing one-quarter of the world's electricity. Although hydropower is usually considered a fully developed energy source, a hydropower construction boom is under way in many countries, particularly in the Third World. During the past five years, ten countries have increased their capacity by more than 57,000 megawatts—the equivalent of fifty-seven large nuclear reactors. Despite debt burdens that have slowed some projects, the World Bank expects hydro capacity to double in the eighties. In China alone, the 10,000 megawatts of hydro capacity under construction in the early eighties will expand the country's hydroelectric output by more than half.

Although justified on strict economic grounds, many large hydro projects cause social and ecological problems. Too often, dams have been constructed without sufficient planning. Inadequate fish-handling facilities have eliminated access to essential spawning areas, reservoirs have expanded the breeding grounds for snails that spread schistosomiasis, and valuable farmland and wilderness areas have been inundated. Indigenous peoples are sometimes forced off their homelands, and their cultures are irretrievably lost. Large hydro projects must be considered carefully before they are undertaken, and some should be foregone entirely.

Wood and hydropower already contribute substantially to the global energy budget, but other renewable energy sources that make only a minor contribution today hold enormous promise for the



There's an Awful Lot of Alcohol in Brazil

No country has put more effort into developing renewable sources of energy than Brazil. With the world's tenth largest economy, a pauper's endowment of fossil fuels, and a foreign debt of $95 billion, Brazil desperately needs to develop indigenous and sustainable energy supplies. In the aftermath of the 1973 energy crisis, Brazil's leaders developed plans to expand hydropower, alcohol fuels, and wood energy, all on a massive scale. Never before has a country developed such a diverse renewable energy program or made renewables such a key part of its development plans.

Brazil is investing tens of billions of dollars in large hydro projects that will provide electricity for cities and industries. Its hydro capacity is scheduled to double by 1993, which could make Brazil second only to the United States in hydroelectric capacity. Symbolic of Brazil's approach to hydropower is the Itaipu project, with a dam five miles long and half the height of the Empire State Building. Estimated to cost $18 billion, Itaipu will be the world's largest hydro project and provide enough power for five million people.

More unusual is Brazil's alcohol fuels program. Launched in the early seventies, the multibillion-dollar Proalcool program provides incentives for turning the country's abundant sugar cane crop into alcohol that can be burned in modified internal combustion engines. Brazil now has 1.2 million automobiles that run on straight alcohol, and another 9 million run on a 2 percent alcohol-gasoline mixture. Overall, alcohol meets 4 percent of the country's automotive fuel needs. Brazil plans t triple production of alcohol fuel by 1993, which, combine with successes in oil exploration, may allow it to reach its go of not having to import oil for cars by the early nineties.

Brazil is working to harness other renewable energy source as well. Scientists are investigating a number of vegetable oi that may one day substitute for diesel fuel in the country's mi lions of trucks. In addition, wood energy has an enormous p tential to provide heat and power for industry. A major pr gram has been developed to shift the steel industry fro metallurgical coal to wood-derived charcoal.

Brazil's renewable energy programs are certainly the mo ambitious and in many ways the most successful. But they a not without problems. Large hydro projects have inundate wilderness areas and displaced native peoples. Alcohol fu production has supplanted some food production and threa ens to exacerbate the country's unequal distribution of incom And Brazil has put surprisingly little effort into improving e ergy efficiency, which could further reduce oil dependence at small cost. Brazil stands as an important example of the ro that renewable energy sources can play in developing countri and of potential problems that must be considered.—*C.P.*

future. One example is solar heating and cooling, a technology that is being developed by private companies in dozens of nations. The big success stories are Japan, which has 4 million solar hot-water systems in place, and Israel, where about half the homes heat their water with solar energy. The United States has the world's largest collector industry and about a million solar buildings in place. But the complexity of the systems must be reduced and their cost lowered to realize their potential.

Geothermal heat is the only renewable energy source that does not depend on sunlight. Iceland's capital city of Reykjavik is almost entirely heated by geothermal steam. Another major geothermal resource is the Geysers (in California), whose steam supplies 1,300 megawatts of electricity, as much as the world's largest nuclear plant. Efforts to harness geothermal resources are under way throughout the Pacific Rim countries. In the Philippines, geothermal capacity is scheduled to double, and lead the world, by the end of 1985. Worldwide geothermal generating capacity rose 20 percent in 1984.

The fastest-growing renewable energy source is wind power, thanks to the new business of "wind farming" begun in California. Since 1981, more than 8,000 turbines have been erected in the state's mountain passes, mostly in Altamont, Tehachapi, and San Gorgonio, where winds blow at an average speed of fifteen to twenty miles per hour. Together, these machines produce enough electricity for 200,000 California households, and their presence provides a powerful visual symbol of California's leadership in the development of renewable energy.

California has some of the country's most concentrated wind resources, and the wind farm boom was spurred largely by small entrepreneurs. Thanks to requirements by California regulators that utilities buy privately produced power at a competitive price, developers are able to raise the capital needed for wind farm development. Funding often comes from limited partnerships in which investors contribute capital in return for tax credits and a share of the electricity revenues. The state also has a 25 percent wind investment tax credit to go with the 15 percent federal credit. In 1984, more than $500 million was invested in 55 California wind farms.

The quality of the wind farm projects varies widely. Although prominent breakdowns have generated negative publicity for wind farms, the performance and reliability of most projects are steadily improving. The average cost of wind turbines has fallen by 50 percent to approximately $1,700 per kilowatt. Calculations based on these figures indicate that the cost of wind power—without tax credits—is less than the cost of power from new nuclear plants. With mass production of somewhat larger machines, wind power will become an economical energy source in many parts of the world.

Wind farming is starting to catch on outside California. Wind farms have been installed in a half dozen U.S. states, and efforts to develop wind power are under way in Europe, particularly in Denmark, Great Britain, the Netherlands, Sweden,

and West Germany. European turbines have turned out to be extremely reliable and are being modified and brought into large-scale production to serve the California market. Many developing countries also have substantial wind power potential, and efforts are being made to identify good sites. North Africa and the Caribbean islands are particularly promising areas for wind farms.

If there is one lesson to be learned from a decade of renewable energy development, it is that efforts to make long-range forecasts about such rapidly evolving technologies are pointless. But there can be little doubt that the dozen or so renewable energy sources, together with improved energy efficiency, can form the foundation of a more sustainable and less environmentally disruptive energy system of the future. Intelligent and sustained government support is one of the keys to realizing this potential.

Christopher Flavin and Cynthia Pollock

Building a sustainable society is possible. But it is not easy.

Population policies and national priorities on resource use will have to be thoroughly overhauled. The cornerstone of such a reorientation is the realization that our security and future well-being may be threatened less by the conflicts among nations than they are by the deteriorating relationship between ourselves, soon to be five billion, and the natural systems and resources that sustain us.

The principal elements of an effort to build a sustainable society are straightforward. They include economic and population policies that respect the carrying capacity of local ecosystems, protect soils, and preserve the diversity of landscapes and species. Any strategy that aims to improve living standards will recognize the depletable nature of fossil fuels. Successful economic plans will capitalize on the abundance of labor and minimize the use of scarce capital.

The ecological indicators of today foreshadow the economic trends of tomorrow. If we are interested in food prices at the end of the century, we should be looking at soil erosion today. For some idea of the cost of lumber and the price of housing a generation hence, we should be following deforestation trends today. If we want to know what types of seafood we will be eating a decade from now, we should be analyzing the areas of overfishing today.

Add the interaction of these trends across international boundaries, and the complex analytical task becomes evident. In effect, the emergence of a highly developed international economy provides a way of transmitting scarcities from one country to another, a domino theory of ecological stress and collapse. In times past, civilizations whose food systems were undermined by erosion declined in isolation. But in the integrated global economy of the late twentieth century, food—like oil—is a global commodity. A country that loses too much topsoil needs to import more food, thereby raising the pressure on soils elsewhere.

Countries that address these challenges face difficult choices. In China, authorities encourage cremation rather than traditional burial to conserve cropland. West Germans may now have to choose between reducing automobile use and sacrificing their forests. For many Third World countries, the choice is between an abrupt lowering of birthrates or a certain decline in living standards.

Trade-offs between food and energy are particularly difficult. In Brazil, a massive government program to become self-sufficient in liquid fuels by producing alcohol from sugar cane has reduced the outlay of scarce foreign exchange for oil, but it has also increased the pressures on soil and displaced small farmers from their land.

Difficult as these choices seem, they pale beside the costs of inaction. India has long advocated family planning, and its population is expected to reach replacement-level fertility by 2010. Yet this slow but steady braking of demographic momentum will keep India's population growing until it reaches 1.7 billion. In effect, India would add the equivalent of China's population to its current numbers. For a country that is now losing some 6 billion tons of topsoil from its cropland each year, the prospect of having to feed another billion people is frightening.

Nigeria faces an equally daunting prospect. If birthrates fall to the level needed to just replace parents by 2035, Nigeria's youthful population will reach 618 million, more than now live in all of Africa. This extraordinary population growth is already being supported with imported food paid for by oil exports, and the oil will be largely depleted by 2000.

Mexico may have also waited too long. Its current population of 73 million is projected to reach 199 million before growth comes to a halt. Water is already critically short, not only in Mexico City but in the central and northern sections of the country as well. With a near tripling of Mexicans in prospect, stringent water rationing seems inevitable.

These population estimates for key Third World countries are official World Bank projections, but there is an air of unreality about them. Although sound in narrow demographic terms, they bear little relation to the deterioration of basic life-support

systems and to the resultant hunger and deprivation. The main question facing political leaders in these countries is whether this unsupportable population growth will be checked by vigorous family planning programs or by starvation.

Although restoring improvements in living standards is a formidable task, all the ways of doing so reinforce one another. For example, planting trees conserves soil and water, slows the buildup of carbon dioxide (CO_2), stabilizes the hydrological cycle, minimizes flooding and drought, provides employment, and creates a renewable source of energy. Similarly, slowing population growth makes virtually all problems much more manageable, as those countries that have reduced fertility are discovering. Increasing energy efficiency cuts down on CO_2 buildup, reduces acid rain and hence protects forests, and provides higher living standards with a given supply of energy. Recycling materials also illustrates this pattern of reinforcement: As recycling increases, energy requirements dwindle, air pollution and acid rain decline, pressure on forests is reduced, and employment increases.

Our effects on natural systems, whether constructive or destructive, will change relationships not only among countries but also between generations. Fossil fuel combustion today promises to alter the climate of tomorrow. Our destruction of plant and animal species impoverishes the world of our children and grandchildren. At issue is whether we can act on behalf of future generations by having fewer children and by shifting to sustainable technologies and consumption patterns.

Lester R. Brown and Edward C. Wolf

Authors and Additional Reading

Lester R. Brown is president of Worldwatch Institute, an independent, nonprofit research organization created to focus on and analyze global problems. With Worldwatch colleagues **William U. Chandler, Christopher Flavin, Cynthia Pollock, Sandra Postel,** and **Edward C. Wolf,** he authored *State of the World 1985: A Worldwatch Institute Report on Progress Toward a Sustainable Society,* edited by Linda Starke and published by W.W. Norton and Company, New York and London, 1985. Most of the material in this supplement was drawn from this extensive work.

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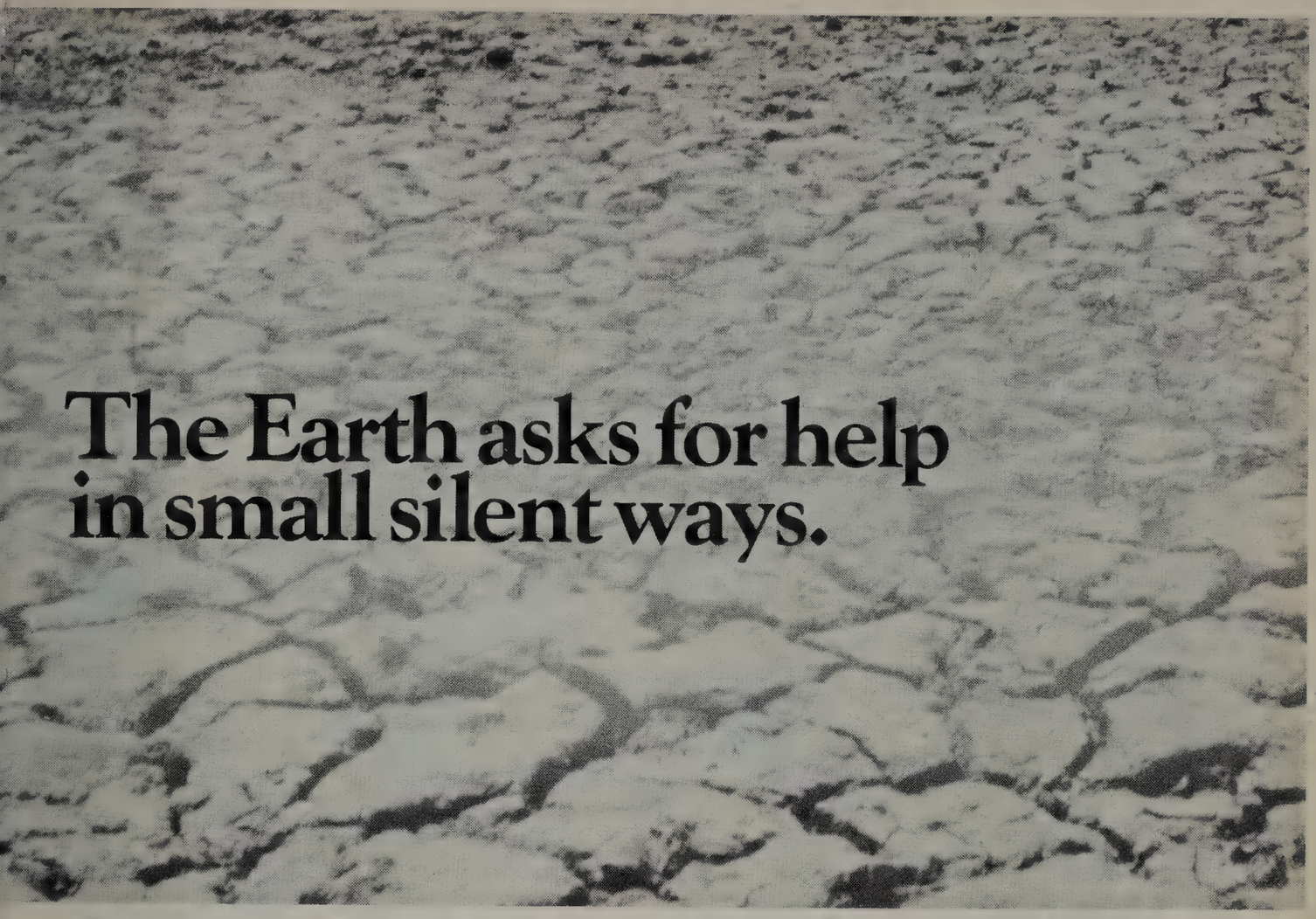
Stephen Schneider and Randi Londer's *The Coevolution Climate and Life* (San Francisco: Sierra Club Books, 1984) i troduces the history, dynamics, and implications for human s ciety of climate changes. William W. Kellogg and Robe Schware's "Society, Science and Climate Change" (*Forei Affairs,* Summer 1982) investigates the modifications in pu lic policy that may be required to cope with rising levels of ca bon dioxide in the atmosphere. In *Acid Rain in Europe a North America: National Responses to an Internation Problem* (Washington, D.C.: Environmental Law Institu 1983), Gregory S. Wetstone and Armin Rosencranz, both a torneys, investigate the national policies and strategies of t United States, Germany, Norway, Sweden, Canada, t United Kingdom, and Japan to control this form of pollutio For a copy, send $14 to the Environmental Law Institu Publications Department, 1346 Connecticut Avenue N Washington, D.C. 20036.

Rita Camp



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Audubon's Mystery Birds

The pioneer American ornithologist left some loose ends

In these days of sophisticated birders, who call for illustrations of every plumage variant in order to simplify the field identification of difficult species, it is hard to imagine the state of American ornithology in the days of John James Audubon. Although many North American birds were well known to Europeans, there were no handy books about them. Audubon's archrival, Alexander Wilson, was the first to attempt to compile a definitive American ornithology but died in 1813 before finishing it. The two pioneer ornithologists met just once, by chance, in Louisville, Kentucky, in 1810. Wilson showed Audubon his first two published volumes and Audubon showed Wilson a portfolio of early drawings. Neither had known before that they shared the same ambition, but from then until Wilson's untimely death at age forty-seven, each was very conscious of his rival's activities, and suspicions and accusations of plagiarism arose.

A large number of the birds that fell to Audubon's gun were new to him, and to the best of his knowledge had not been previously described. In the first edition of *The Birds of America* (published 1827–1838), Audubon provided English and scientific names for all of them. In some instances, after examining specimens and books in London and elsewhere, Audubon learned that a species had already been named in an earlier published work. He acknowledged this in his later writings, but in most cases, he continued to believe that he had discovered a new species.

Bird watchers today are more familiar with the striking plumage differences between the sexes and age classes of many common American birds. Collection and field observation since Audubon's day have shown that many of his new species wer simply plumage variants of well-known birds. For example, hi controversial bird of Washington is an immature bald eagl The hemlock warbler, whose discovery Audubon graciousl credited to Wilson, proves to be the female of the Blackburnia warbler, a species whose brilliantly colored male was known t both authors.

Some of Audubon's discoveries remain valid, but not neces sarily as species. Five "kinds" of woodpeckers he illustrated i one plate are hairy woodpeckers from various parts of th United States (and not all are valid subspecies).

In 1822, Audubon shot a handsome duck in Louisiana that h first thought was the obscure bimaculated duck (not bemacu lated, as often spelled). After comparing his drawing with spec mens in London, however, he decided it was a new species an named it Brewer's duck, in honor of his friend Thomas Brewe At the same time, however, he conjectured that his specime was a hybrid rather than a new species, suggesting the mallar and the gadwall as possible parents. This crossing has since bee recorded many times, both in the wild and in captivity; Audu bon's guess turned out to be correct.

Five of Audubon's species have puzzled subsequent genera tions of ornithologists. Two birds, the Blue Mountain warble and the small-headed flycatcher, appear in one plate with a mis cellany of well-known species. The warbler was discovered b Alexander Wilson near the Blue Mountains of Pennsylvania Audubon never saw the species alive, but stated that his descrip tion and drawing were "taken from a specimen lent to me by th

by Kenneth C. Parkes

Audubon's illustration of what he called carbonated warblers was based on two male specimens he shot in Kentucky in May of 1811. Were they Cape May warblers in their first spring?

All photographs by AMNH

What Audubon thought was a separate species, which he named the bird of Washington, was actually an immature bald eagle.

ıncil of the Zoological Society of London, and which had
ıe from California." Its wing bars, white-spotted tail feath-
and streaked sides all suggest a wood warbler of the large ge-
Dendroica, but no species belonging to that genus combines
se characters with the sharply delineated yellow forehead
unstreaked back shown in Audubon's illustration.

Audubon tells us that in the early spring of 1808 he shot and
w a small unknown bird at Louisville, Kentucky. This draw-
was among those he showed to Wilson, who, Audubon
med, copied it and published it, identifying it as a small-
ded flycatcher, *Muscicapa minuta*, without giving proper
dit. Wilson wrote that he saw the bird in various parts of New
sey and shot one on April 14. Audubon searched that state in
ı for the species. (Of course, if Wilson did shoot one in mid-
ril it may well have been a migrant.) Audubon states that he
er saw another specimen of this species in any museum or pri-
e collection.

Several of the wood warblers that forage by hawking after fly-
insects were called flycatchers by Wilson, Audubon, and
er early authors, and the description of *Muscicapa minuta*'s
its indicates that it probably belonged to this group. But
e are known to have the combination of white eye ring and
te wing bars assigned to this mysterious species.

Many writers ascribe such discrepancies to faulty memory on
dubon's part. Although the published figure of the small-
ded flycatcher was drawn as late as 1838, Audubon states
the drawing and his description were copied directly from
original sketch and notes of 1808. An alternative explanation
the confusing characters of both the Blue Mountain warbler
the small-headed flycatcher is hybridization, which we now
w occurs among warblers more frequently than once be-
ed, often between surprisingly dissimilar parent species.
king the actual specimens, we can only guess what unions
ht have produced these unique combinations of characters,
perhaps appropriate matches will someday be found.

ome suggest the Cuvier's wren that Audubon shot in Penn-
ania in 1812 was also the result of hybridization. His illustra-
seems to combine the colors of two little birds, the ruby-
wned and golden-crowned kinglets. But the structural
racteristics of the plumage mentioned in the text—such as
"small decomposed feather covering the nostril"—are all
cal of the golden-crowned. George Watson of the U.S. Na-
al Museum of Natural History concludes that this was noth-

*traits of Audubon's Blue Mountain warbler and small-
ded flycatcher (left and right, beneath the uppermost bird)
ot match those of any known species.*

A bird Audubon called Cuvier's wren is not a wren; it most closely resembles a golden-crowned kinglet.

ing more than a golden-crowned kinglet whose crown patch w bright red rather than the normal yellow with an orange cent

Another one of Audubon's mystery birds is the carbonat warbler, whose illustration and description were based on t males Audubon shot in Kentucky in May 1811. As long ago 1832, the British ornithologist Sir William Jardine suggest that these birds were Cape May warblers, and Audubon hims postulated that his specimens were young birds from the prec ing year, "not in full plumage." In their first spring, male Ca May warblers differ from older males in that the orange-bro cheek patch is reduced or practically absent and the white wi bar is much narrower. These features exactly match Audubo plate of the carbonated warbler, so it is probably not necessary look any further for a plausible explanation.

Perhaps the most intriguing mystery bird is Townsen bunting, *Emberiza townsendi*, which Audubon named for discoverer, John K. Townsend. This is the only mystery b whose specimen still exists. It is kept in a locked cabinet in t National Museum of Natural History in Washington, wher have been privileged to examine it. Although several theor have been advanced, no ornithologist has ever ventured to id tify it definitively. The bird's general conformation agrees w that of the dickcissel (*Spiza americana*), so most authors ten tively place it in the genus *Spiza*. It certainly does not belong *Emberiza*, the genus of Old World buntings.

Although Audubon said nothing about the circumstances Townsend's discovery of this bird near Philadelphia, Tow send's notes were later published in *The Auk*, the journal of t American Ornithologists' Union. After rereading these, I ha come to believe the specimen probably represents a dickcis that lacked the normal carotenoid (yellow) pigments in its plu age, having only the browns, blacks, and grays produced by m anin pigments. Such pigment deficiencies, resulting from mu tions or failures in development, are well known in some otl groups of birds. The absence of yellow pigments, for examp produces the blue variety of the familiar green budgerigar, parakeet. The plumage pattern of Townsend's bunting (allow for the subtraction of yellow) is that of an adult female dick sel, but according to Townsend's description, his specimen wa male. Perhaps an abnormality resulted in the absence of yell pigment and, at the same time, prevented the bird from assu ing the normal plumage of the adult male. The fragile remains this bird cannot really tell us the answer.

The original specimen of one of Audubon's mystery birds, Townsend's bunting (lower left), still exists, but it has not bee definitively identified.

Brown thrashers being attacked by a black snake, an Audubon watercolor.
The New-York Historical Society, N.Y.C.

Painter of the Feathered Tribe

udubon and his work were one,
ived in his work, and in his work will live forever"

Phillip Drennon Thomas

wo hundred years ago this month, on then prosperous island of Santo Do-go (Hispaniola), John James Audu- was born to a French sea captain and sland mistress. Essentially self-taught ience and art, by the time of his death 851 he had left an indelible mark n American natural history and art. rges Cuvier, the founder of compara- anatomy, proclaimed that with *The ls of America*, Audubon had created most magnificent monument which yet been raised to ornithology." Audu- was a talented field naturalist with powers of observation. Nevertheless, late in his life, he had but limited wledge of the technical dimensions of thology. Although he may be the most ely recognized of America's nine- th-century artist-naturalists, he is re- nbered, not for any specific scientific ribution, theory, or idea, but rather for rt. Frequently criticized by his contem- ries for a lack of attention to scientific il, Audubon could never be accused of ng to appreciate the splendor of the s he pursued with such passion.

udubon's mother died a few months r his birth, and his father left the is- in 1789. Two years later, with a half- r who had also been born on the is- , Audubon rejoined his father, who settled in Nantes, France. In 1794, children were formally adopted by his er and stepmother. Audubon's early eriences at school in Nantes were ked by frequent absences. He later ob- ed that "almost every day, instead of g to school where I ought to have e, I usually made for the fields, where I t the day." He returned home each ning with "curiosities, such as birds' s, birds' eggs, curious lichens, flowers of all sorts, and even pebbles gathered along the shore of some rivulet." Audubon's father wished for him to become a naval officer; his stepmother, a priest. After attending a midshipmen's school at Rochefort-sur-Mer for three and one-half years, Audubon had made little progress toward a naval career other than becoming somewhat skilled at tying knots. His future as a seaman seemed limited. A persistent but undocumented assertion is that during his early years he studied in Paris with the famous French painter Jacques Louis David. If Audubon was, as he said, a "pupil of David," it apparently was for a brief period and of little lasting consequence.

So that he might avoid conscription in Napoleon's army, Audubon was sent to America in the late summer of 1803 to help supervise two hundred acres his father had acquired near Mill Grove, Pennsylvania. With imperfect English, learned from Quaker nurses who attended him while he was ill with yellow fever, he began to establish himself in America. Dressed in silk and satin, admired for his marksmanship, swimming and riding abilities, and the "elegance of his figure and beauty of features," Audubon explored the fields and forests of his new home on a branch of the Schuylkill River. Stuffed squirrels, raccoons, opossums, fishes, frogs, snakes, lizards, and birds' eggs soon adorned his room. His early years at Mill Grove were an idyllic but fleeting episode in his new American experiences: "Hunting, fishing, drawing, and music occupied my every moment; care I knew not, cared naught about them." In 1804, Audubon became enchanted with Lucy Bakewell, the seventeen-year-old daughter of his English neighbors.

Audubon continued observing and sketching the birds of eastern Pennsylvania. Fascinated by the return of phoebes to a cave on his estate, he tied silver threads around the young to see if they would return the following year. This was the earliest known case of bird banding in America and reveals Audubon's ability to design a method to answer an important question about bird behavior. A century passed before bird banding became a more common practice.

During this period Audubon began to use wires to hold freshly slain birds in position while he sketched them. This allowed him to arrange birds in more lifelike poses than could be found in mounted specimens. Audubon could not draw a particular species of bird accurately without a specimen before him, and throughout his career he enthusiastically shot birds for study and sketching. (On occasion he also ate the birds he shot.) Naturalists had traditionally prepared their sketches from stuffed specimens, but Audubon maintained "that *feathers* lose their brilliancy almost as rapidly as flesh or skin itself" and "that a bird alive is 75 percent more rich in colours than twenty-four hours after its death."

Over the years, Audubon kept progressively better field notes on the species he was studying. He often spent fourteen to seventeen hours working on a drawing and sometimes abandoned the task only when the decomposing specimen made the work unpleasant. Dissection of their stomachs enabled him to learn more about birds' feeding habits. Although he was a perceptive observer, he had difficulty portraying birds in motion. His birds in flight were among the most awkward of his representations, but this was an age when there

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Audubon labored fourteen days to paint this golden eagle with a snowshoe hare in its talons. He regarded it as one of his most successful works. The figure in the lower left corner is thought to be a self-portrait; it was eliminated in the plate for the printed version.

The New-York Historical Society, N.Y.C.

were no photographic records of such complex motion to serve as a guide.

In April 1808, Audubon wed Lucy Bakewell. Their marriage began somewhat inauspiciously when they left on a twelve-day journey to their new home in Louisville, Kentucky. While crossing the Alleghenies, their carriage overturned, and Lucy was severely bruised. In Louisville, Audubon and a partner operated a gen store for two years, but with little succ Years later Audubon observed, "We many goods and opened a large stor Louisville, which went on prospero when I attended to it; but birds were b then as now, and my thoughts were and anon turning toward them as the jects of my greatest delight. I shot, I d

ooked on nature only; my days were
ppy beyond human conception, and be-
nd this I really cared not." His first son,
ctor Gifford Audubon, was born on
ne 12, 1809. Audubon's devotion to
ds continued to divert attention from
business. "Therefore," he wrote, "my
siness abandoned me."

More momentous for Audubon's career
s his 1810 meeting with Alexander Wil-
, who shared with Audubon a love for
nerica and a passion for the nation's
ds. When Audubon met him, Wilson
s seeking subscribers at $120 a set for
American Ornithology. Years later,
ile in Great Britain promoting his own
rk, Audubon wrote, "How often I
ught during these visits of poor Alexan-
Wilson. When travelling as I am now,
procure subscribers, he as well as my-
was received with rude coldness, and
netimes with that arrogance which be-
gs to *parvenus*." Audubon remarked
t Wilson died under the "lash of a
kseller."

Wilson had even less economic success
n Audubon and was at various times in
career a poet, weaver, printer, peddler,
veyor, and schoolteacher. In March of
10, when Audubon examined the first
volumes of Wilson's work, he was at
point of subscribing to the series, but
business partner advised against it.
What induces you to subscribe to this
rk?" he asked. "Your drawings are cer-
nly better, and again, you must know as
ch of the habits of American birds as
s gentleman." Given the state of Audu-
n's business finances, this advice may
ve been as much a reflection of eco-
mic realities as a judgment of the value
Wilson's work.

Wilson, like Audubon, made technical
ors in his observations and descriptions
birds, but his ornithological knowledge
s superior to Audubon's. Yet Audu-
n's birds have a vitality, brightness, and
eliness seldom found in Wilson's small-
plates. Wilson was a self-trained or-
hologist who painted birds to illustrate
works; Audubon was a self-trained art-
who studied ornithology to comple-
nt his magnificent bird portraits. Per-
ps, as some suggest, the meeting with

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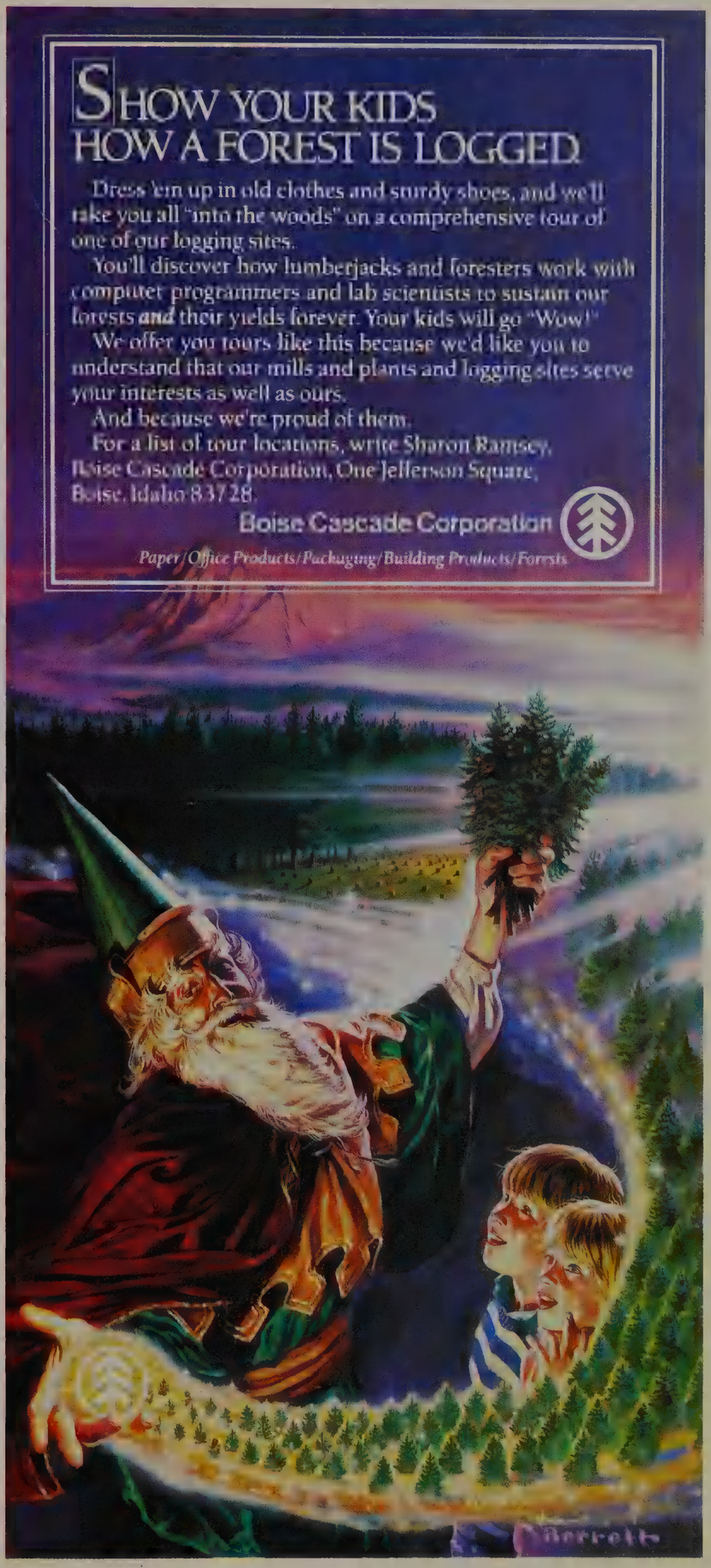

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This portrait of Audubon was painted by his sons, John and Victor. A gun was one of the tools of Audubon's trade—throughout his career as a naturalist-artist, he relied on shooting birds for study. Sometimes he ate the birds he shot and offered comments on their palatability.

AMNH

Wilson initiated Audubon's dream of having his own expanding portfolio of bird portraits published.

In the summer of 1812, Audubon became an American citizen, and in November of that year, his second son, John Woodhouse Audubon, was born. Audubon also had two daughters, who died in infancy: Lucy, born in 1815, died in 1817, and Rosa, born in 1819, died in 1820.

Audubon's lack of commitment to his Louisville business was followed by almost a decade of further economic disappointments and the depletion of his wife's inheritance. He failed in the construction of a steam grist- and sawmill at Henderson, Kentucky. In an 1819 steamboat endeavor, he persuaded the brother and family of the poet John Keats to invest in his speculations. Although the details of this matter are unclear, Keats could not help thinking "Mr. Audubon a dishonest man," who made his brother believe "that he was a Man of Property." Further dissension arose when Audubon, his arm in a sling as a result of a steam engine accident, was attacked by a business associate. After receiving twelve blows from his bludgeon-swinging assailant, Audubon struck him down with his dagger. The community was enraged by Audubo method of defense, but a judge later ru that Audubon committed a "serious fense, an exceedingly serious offe Sir—in failing to kill the damned rasc

His cavalier attitude doomed Audu to failure in business, and in 1819, he jailed briefly in Louisville for debt. leased upon a declaration of bankrup with nothing left but what he deemed "humble talents," he began to do portr in black chalk of the human "head vine." Within a few weeks he was abl earn enough to rent a house in Louisv Never modest about his abilities, Au bon claimed he was even called into countryside to prepare "likenesses of sons on their death-beds" and that a c gyman had had his dead son exhume that a portrait could be made. Still, Au bon wrote, "My drawings of birds w not neglected meantime; in this particu there seemed to hover around me almo mania and I would even give up doin head, the profits of which would have s plied our wants for a week or more, to r resent a little citizen of the feathe tribe."

Audubon then moved to Cincinnati worked briefly as a taxidermist at Da

ake's Western Museum. When the omised monthly salary could not be et, he drifted south to New Orleans to ntinue painting portraits in black chalk d birds in watercolors and pastels. He ll had a difficult time maintaining him- f and provided little support for his fam- ; Lucy did not join him for more than a ar. When she moved to New Orleans, e found a position as a governess on a ntation, and later as a teacher on the tensive plantation of Jane Middlemist rcy in West Feliciana, Louisiana. For a ne, Audubon traveled to Natchez to int. There he received a brief introduc- n to the use of oils in painting from John ein, an itinerant artist.

Despite frequent economic reversals, cy continued to encourage her hus- nd. Audubon wrote, "My wife deter- ned that my genius should prevail and at my final success as an ornithologist ould be triumphant." To cultivate this ccess, Audubon had to find a method of aring the results of his studies and paint- gs of birds with a wider audience. This quired the publication of his growing rtfolio of bird paintings.

During the nineteenth century, Phila- lphia was the center for the study of nat- al history in America. Audubon arrived ere in 1824, intent on acquiring a pub- her, but his arrogance alienated some of e city's leading naturalists. When a pub- her could not be found there or in any ner American city, Audubon elected to ek support abroad.

Both he and Lucy began to save their nited resources. To provide funds for his ropean trip, Audubon taught French, ncing, and fencing. In May of 1826, he led alone for England. He had $1,700, sentially his wife's savings, to begin a oject that would ultimately last almost a zen years and cost more than $100,000. ter disembarking at Liverpool, on July , 1826, and paying a duty of two pence each watercolor that he brought into e country, Audubon, with some trepida- n, began his artistic conquest of the itish Isles.

England's interest in the natural history her former colony was strong. Bar- m's *Travels* had won a wide audience

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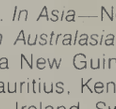
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The wild turkey cock, which Audubon painted in Louisiana, was the basis for the first plate published in The Birds of America.
The New-York Historical Society, N.Y.C.

in England and had influenced Coleridge and Wordsworth. There was a growing romantic interest in the exotic peoples, flora, and fauna of North America. Within seven days of his arrival, Audubon had been invited to exhibit his drawings at the Royal Institution of Liverpool, where his works were displayed for more than month. More than four hundred viewe attended the second day of the exhibitio Audubon, with his long chestnut ha flowing to his shoulders, played upon h image as a citizen of the American wilde ness. He would recite accounts of his a

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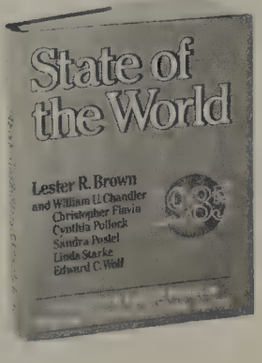

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A print of the hooded merganser, based on a painting Audubon made in New Orleans in 1821, lies in its original shipping box.
AMNH

ventures in the wilds with Indians, Daniel Boone, bears, wolves, and frontier settlers; and if the audience's attention waned he would fill the room with wolf howls and bird calls. To the frequent questions about the dangers of bears, wolves, and foxes, Audubon coolly replied that he was never "troubled by any larger animals than ticks and mosquitoes." His "American Woodsman" image subsequently helped Audubon sell his works.

The accolades bestowed upon Audubon and his work were the first public acknowledgments of his talent that he had ever received; and while he admitted to a certain weariness from the frequent bowing that was part of receiving guests at the exhibition, he rejoiced in the praise that accompanied it. In a letter to his wife, he wrote, "I am well received everywhere, my works praised and admired, and my poor heart is at last relieved from the great anxiety that has for so many years agitated it, for I know now that I have not worked in vain."

Although he was graciously received in Liverpool, he did not find a publisher, and thus set forth for Edinburgh. There, the prominent Scottish engraver W. H. Lizars was delighted by Audubon's work and agreed to print ten of his paintings to test the market. The first plate produced was the *Wild Turkey Cock*, followed by prints featuring the yellow-billed cuckoo, p thonotary warbler, purple finch, and Ca ada warbler.

Lizars also introduced Audubon to E inburgh society. Audubon met Sir Wal Scott, whose movements he watched as they were those of "a celestial being Scott commented in his journal:

He is an American by naturalization, Frenchman by birth; but less of a Frenc man than I have ever seen—no dash, glimmer, or shine about him, but great si plicity of manners and behaviour; slight person, and plainly dressed; wears lo hair, which time has not yet tinged; countenance acute, handsome and intere ing, but still simplicity is the predomina characteristic. . . . This sojourner in t desert has been in the woods for months gether. He preferred associating with t Indians to the company of the Back S tlers; very justly, I daresay, for a civiliz man of the lower order—that is, the dre of civilization—when thrust back on t savage state becomes worse than a savag

The success Audubon had known Liverpool was repeated in Scotland's ca tal, and his head was even cast by a pron nent phrenologist. A French critic w viewed his works in Edinburgh co mented,

A magic power transported us into the fo est which for so many years this man of g

s has trod. Learned and ignorant alike
e astonished at the spectacle, which we
not attempt to reproduce. Imagine a
dscape wholly American, trees, flowers,
ss, even the tints of the sky and the wa-
quickened with a life that is real, pecu-
trans-Atlantic. On twigs, branches, bits
hore, copied by the brush with the strict-
fidelity, sport the feathered races of the
w World, in the size of life, each in its
ticular attitude, its individuality and pe-
arities. . . . It is a real and palpable vi-
of the New World, with its atmosphere,
mposing vegetation, and its tribes which
w not the yoke of man. . . . This realiza-
of an entire hemisphere, this picture of
ature so lusty and strong, is due to the
sh of a single man; such an unheard of
mph of patience and genius!—the resul-
t rather of a thousand triumphs won in
face of innumerable obstacles.

n March of 1827, the first five prints
e ready, and Audubon began the task
finding subscribers for *The Birds of*
erica. Arriving in London to sell sub-
ptions, Audubon learned that Lizars's
orists were on strike and production of
prints had ceased. The good fortune
t had been denied Audubon in earlier
rs now appeared, and Robert Havell, a
ndon engraver, assumed responsibility
the production of his works. His son,
bert Havell, Jr., played a crucial role in
production of *The Birds of America*.
eleven years, he supervised the en-
ving of the 435 plates with their 1,065
ures. As Audubon observed, the con-
uity of production was not broken for a
gle day. Given the immensity of the
ject and the quality Audubon de-
nded for his life-size prints, this was an
omplishment of the highest order.
ch plate was printed on handmade pa-
29½ by 39½ inches. (Once his task
s completed, the younger Havell emi-
ted to America and settled along the
nks of the Hudson River, where he re-
d his skills as a landscape painter.)
The major tasks of publishing *The*
ds of America, however, were left to
dubon. To find the money needed daily
pay the colorists and engravers, Audu-
n painted canvas after canvas of Ameri-
n wildlife scenes, and then, with the oil
ely dry, sold them door to door in Lon-
n. In his wolfskin coat with portfolio on

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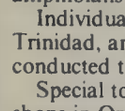

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Mill Grove Farm, Pennsylvania, was purchased by Audubon's father before he settled in France. In 1803, to avoid conscription in Napoleon's army, Audubon was sent to America to help supervise the property. Thomas Birch painted this view of the farm in the 1820s.

The New-York Historical Society, N.Y.C.

his shoulder, he was a sight unrivaled on the London streets. The influential periodical *Athenaeum* stated that "he was not a man to be seen and forgotten, or passed on the pavement without glances of surprise and scrutiny . . . the clothes not made by a West-end but by a Far West tailor, the steady, rapid, springing step, the long hair, the aquiline features and the glowing angry eyes . . . and an air and manner which told you that whoever you might be he was John Audubon."

At one point, Audubon commented, he had only one sovereign left in his pocket. "I extricated myself from all my difficulties," he wrote, "not by borrowing money, but by rising at four o'clock in the morning, working hard all day, and disposing of my works at a price which a common labourer would have thought little more than sufficient remuneration for his work." It was Audubon who had to find the subscribers, prepare the drawings for the engravers, inspect the color of the prints, and deliver the prints upon completion. For the publication to continue, money had to be continually raised. The work was expensive, selling in England for 182 pounds and 14 shillings a set, and in America for $1,000. Not surprisingly, individuals would subscribe and then drop out.

In 1829, Audubon returned to Amer to prepare additional drawings and to p suade his wife and sons to join him in E land. A year later, the family moved England and began to enjoy modest pr perity. All future publications becam family enterprise, with Audubon's t sons playing a major role.

By 1830, Audubon had initiated publication of a work illustrating the bi of his homeland, but he had not really p vided any sustained discussion of their histories and appearances. Sensing t the scientific descriptions were beyond ability in English and his knowledge anatomy, he began a collaboration w the gifted young naturalist Willi MacGillivray of the University of Ed burgh. MacGillivray labored diligen with Audubon to produce the five v umes of the *Ornithological Biograph* (1831–39). In addition to providing formation about the birds portrayed *The Birds of America*, this work includ sixty brief essays entitled *Delineations American Scenery and Manners*, in whi Audubon described a quarter of a cen ry's adventures and commented upon t people and places he had encounter during his frontier days.

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In Salem, New York, Maria R. Audubo (seated) and Florence Audubon posed before a likeness of their grandfather. The portrait, by their father, John Woodhouse Audubon, now hangs in the National Portrait Gallery.

AMNH

bon returned to America in 1831 to obta more southern specimens. With respe for his growing fame, the U.S. gover ment provided revenue cutters to aid A dubon in his work in Florida in 1831–3 The following year he chartered a scho ner and explored the coast of Labrad After another sojourn in England fro 1834 to 1836, Audubon returned to Ame ica to acquire still more specimens. T Philadelphia Academy of Science fru trated his initial attempts to study the c lection of bird skins made by Thom Nuttall and John K. Townsend on the trip across the Rockies to the Pacific, b ultimately Audubon was able to purcha ninety-three duplicate skins of these we ern birds. In 1837, on another birdi expedition, Audubon met Sam Housto president of the recently established R public of Texas.

By 1839, the publication of *The Bir of America* was complete, and the Aud bon family was enjoying unaccustome prosperity and prominence. Close to 2 sets of the work were finally sold, but t cost of this large and magnificent editi

beyond the means of most individuals. answer the needs of a broader public, dubon and his sons decided to prepare maller edition with the plates litho- phed rather than engraved. Audubon joined with John Bachman, a distin- shed Lutheran minister in Charleston, uth Carolina, to prepare a study of rth American mammals.

Bachman's knowledge of the smaller mmals was far superior to Audubon's, he often warned Audubon of the care patience needed in their work. Ever wanderer, Audubon journeyed up the ssouri River in 1843 to collect addi- nal specimens for the study. This scien- cally inconclusive trip was Audubon's major field trip. As Audubon's eyes faculties weakened in the late 1840s, son John assumed responsibility with chman for the study on mammals. But ir work, *The Viviparous Quadrupeds North America* (1845–48), never re- ved the recognition or praise that at- ded *The Birds of America*. Audubon's t years were spent at Minnie's Land, a rty-five acre estate on Manhattan is-

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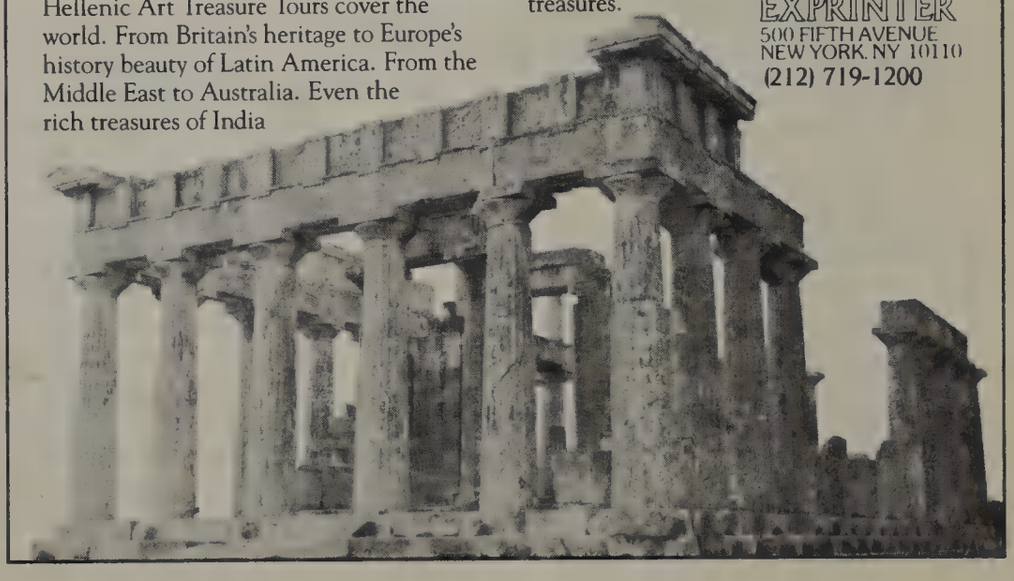

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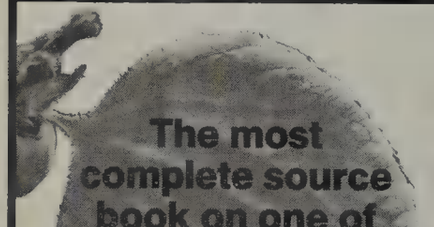

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The great white heron in Audubon's watercolor is now considered a variant of the great blue heron. Audubon first spotted these birds in the Florida Keys, captured a few, and gave them to one of his collaborators, John Bachman, who kept them as pets.

The New-York Historical Society, N.Y.C.

land, overlooking the Hudson River. He died there on January 27, 1851.

In a letter to the prominent portraitist Thomas Sully, Audubon had observed,

> the greatest portion of my life has been devotedly spent in the *active* investigation of Nature, her beauties & her objects in granting to different individuals, classes, or species, such privileges as best suit their form, situation, or habits. This arduous task I have followed with unremitting diligence, and with a degree of industry that has caused my family and to myself more troubles than any person in Philadelphia can be aware of.

Audubon boasted to his son Victor that *The Birds of America* would become "the standard of American ornithology," but the work never achieved that distinction. As an artist, however, he attained a level of recognition never equaled by any other American wildlife artist. Audubon was consumed by his mission, and in the words of the distinguished naturalist Elliot Coues, "Audubon and his work were one, he lived in his work, and in his work will live forever."

Although Audubon had his scientific limitations, these were often shared by other nineteenth-century ornithologists. His powers of observation and ability to make taxonomic distinctions enabled Audubon to describe one new genus, twen three new species, and twelve new subs cies. The plates of *The Birds of Amer* represented almost 60 percent of the s cies in America. Audubon initiated first bird banding experiment in Ameri and in later experiments he sought to de onstrate the turkey vulture's ability to fi food through smell. Contemporary crit who assailed Audubon for his many su posed mistakes were later found to ha erred also. His famous 1827 print showi mockingbirds defending their nest agai a rattlesnake subjected him to ridicule, it was maintained that rattlesnakes did climb trees and that their fangs did bend upward at the tips. Later studies v dicated Audubon's drawing on bo counts.

With his life-size drawings of birds their appropriate habitats, Audub transformed scientific illustrations in art. Although the pressure and expense meeting the publication schedule led certain expediencies that reduced t quality of the final plates of his gre work, Audubon's watercolors and e gravings are almost always filled wi strength, action, and color. With th careful, realistic execution and consiste narrative theme, these works are the e during legacy of John James Audubon.

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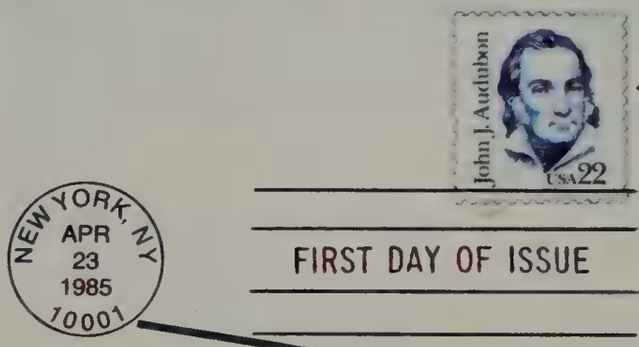

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The *Official* First Day Cover will bear the *Summer Tanager*, an Audubon painting meticulously reproduced from the famed engraving which Audubon himself commissioned in 1826, as a legacy for future generations of mankind. Significantly, many such Audubon works are presently on display at the American Museum of Natural History in New York City.

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Audubon's Coppers

The American Museum of Natural History contains many interesting hidden areas, but few are as impressive as the Audubon Hall, open only by special arrangement with the Museum's Ornithology Department. Paintings, prints, drawings, and other memorabilia of John James Audubon and his sons cover the hall's wood-paneled walls. The lighting is dim—to protect the watercolors—and the aroma of old wood permeates the room. Here, in a glass case, is Audubon's wooden palette, burnished with age. Next to it are half a dozen bird skins—some from extinct species—from Audubon's personal collection. Another case displays his guns, a brace of pistols, and a set of buckskins given to him by Indians. Several portraits of the artist hang on the walls, along with oil paintings and engravings of birds, several original watercolors for *The Viviparous Quadrupeds of North America*, and his portfolio, in which he carried prints from *The Birds of America* to show potential subscribers.

Among these Audubon treasures are a number of dull copper plates hanging high on the walls. These are some of the original engraved plates used to print the *The Birds of America*. Of the 75 or so extant plates (originally there were 435), the Museum owns 12. To mark the two hundredth anniversary of Audubon's birth, which falls on April 26, 1985, the Museum is issuing a new edition of 6 prints from *The Birds of America*, struck directly from the original plates. The subjects of these 6 plates, among Audubon's finest, are the *Wild Turkey, Male;* the *Female Turkey with Young;* the *Snowy Owl;* the *Mallard Duck;* the *Canada Goose;* and the *Great White Heron.*

In 1838, when the first edition of 435 plates was completed at Robert Havell's workshop in London, Audubon arranged to have the plates shipped to America, where they could be restruck. Although he had planned to run off 500 sets for the first edition, he sold fewer than 220 sets. Still, Audubon often expressed his intention of issuing a new edition. But a series of misfortunes, combined with a lack of funds, prevented him from carrying out his plan, and most of the plates eventually disappeared.

Twelve of the surviving plates are on display in the Museum. The details of their journey from London to Central Park West are lost to history, but a number of romantic stories have been told to explain their appearance. They were supposedly salvaged from the bottom of New York Harbor, burned in a great fire, ar rescued at the last minute while beir loaded into a furnace.

In 1839, before their transatlantic jou ney, Audubon insured the plates (or co pers, as he sometimes called them) f $5,000. An excellent account of the fac and myths surrounding the history of th plates can be found in *The Double El phant Folio*, by Waldemar Fries.

According to Fries, who did an exhau tive investigative job, the 435 plates le London in March 1839 and landed in Ne York in May. In one doubtful account, th ship carrying the plates sank in New Yor Harbor and lay there for several montl before a salvage operation could be unde taken. When they finally were hauled u to the surface, the plates were alleged

A new print of the Mallard Duck, *struck from the original copper plate in the Museum's collection*

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covered with copper oxides. We do know that Audubon consigned the plates to a "Mr. Hall's store," where they remained until 1845. In July of that year, a great fire in New York destroyed Hall's warehouse and damaged many of Audubon's plates. Shortly thereafter, Audubon wrote a letter to a friend at the Smithsonian: "We are now engaged in trying to restore [the plates] wonted former existence; although a few will have to be reengraved for use, if ever the work is republished in its original size at all." Audubon had hoped the plates would be a steady source of income for himself and, especially, for his children.

Audubon died in 1851 without having realized his plan to produce a new edition. His widow, Lucy Audubon, built a small shed (called the cave) on the family estate to store the plates. She made various attempts to sell or give the plates to national institutions, but nothing came of her efforts. By 1870, financial difficulties had forced her to consign the plates to an auction house. But the auction went poorly—no one was interested in the plates as art. In 1871 the plates were sold as scrap copper, to be melted down into bars. "There is something almost sad," the *New York Times* reported in March 1871, "that the original plates of that magnificent work, Audubon's 'Birds of America,' were recently sold in this city for their value as old copper, after having vainly sought a purchaser upon their artistic merits."

In 1870, Lucy Audubon had 350 plates, probably those not badly damaged in the 1845 fire. In the next few years, most of these plates were dispersed and lost, but a number of them showed up at the Ansonia Brass and Copper Company, in Connecticut. The company's president, William Dodge, was one of the founders of the American Museum of Natural History. There are two accounts of how some of the best plates were saved from the furnace. The first is that Dodge saw them at his refinery, recognized their value, and saved those that were in good condition.

A slightly different story was recounted by Charles A. Cowles in a letter to Ruthven Deane, published in 1908 in *The Auk*, the journal of the American Ornithologists' Union. Cowles wrote:

> Some time about the year 1873, there were found a number of Audubon copper plates among the scrap copper sent to the refinery of the Ansonia Brass & Copper Company at Ansonia, Conn., to be converted into copper bars. . . .
>
> At that time I was about fourteen years old. . . . I happened to be at the refinery watching the process of loading one of furnaces, and noted on one of the sheets copper that a man was throwing into furnace, what appeared to me to be a p ture of a bird's foot. . . . I made an imme ate but unsuccessful request to the forem of the furnace not to melt the plates; a then I appealed to the superintendent, without avail. I next brought the matter the general manager of the concern, my ther, from whom I received no encoura ment. . . . I hastened back to the works i state of mind so determined that I s ceeded in having all of the plates that h not been melted removed to a place safety. . . . The plates were subsequen submitted to a treatment which removed oxidation and then taken to the main off of the company, and to the best of my r ollection, distributed as follows: Mr. W Dodge, president of the company had a f plates sent to the American Museum Natural History, New York City, and a f plates to the Smithsonian Institutio Washington, D.C., and I think retained o or two for himself. . . . I have sent two pla to Miss M.R. Audubon. . . .

Dodge did give away the plates, Cowles wrote (some also went to the M ropolitan Museum of Art and Princet University), and he did keep "one or tw for himself; Cowles's story seems to true, though perhaps embellished. Dod

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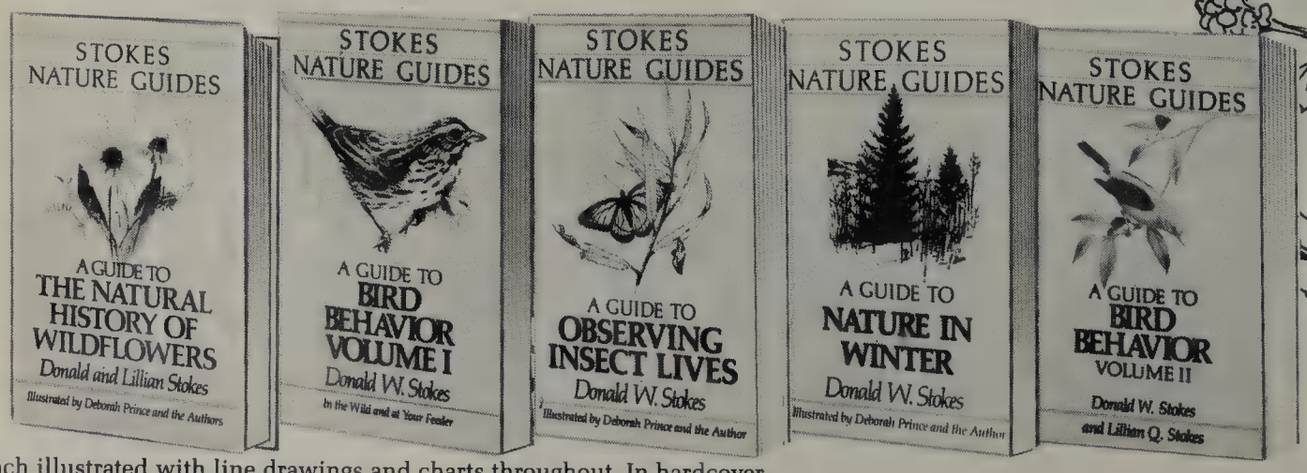
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ably gave nine plates to the American seum, including four that appear in Museum's new edition: the *Snowy* , the *Female Turkey with Young*, the *ada Goose*, and the *Mallard Duck*. ria and Florence Audubon, Audubon's ddaughters, gave their two plates to Museum; one, the *Great White Heron*, so included in the new edition. Finally, 979, Cleveland Dodge, grandson of liam Dodge, gave the Museum plate nber I, the *Wild Turkey*, which ught the Museum's holdings to twelve. everal years ago, the Museum decided oin forces with a British firm, Alecto torical Editions, to create a new edi- from the Museum's best six plates. cto had recently taken on a monumen- project for the British Museum, the ting of Joseph Banks's *Florilegium*, a es of more than seven hundred copper ravings discovered in the storerooms of British Museum (Natural History). graved in the late 1700s to illustrate anical specimens collected on Captain k's voyage to Australia, the work had er been printed, and Alecto was under- ng the first edition some 200 years e." Since Alecto had considerable ex- ience in eighteenth- and nineteenth- tury copper engravings, the Museum the firm should handle the Audubon es. Thus, in 1984, six of Audubon's es returned to London for the first e in 150 years, to be cleaned, restored, printed in an edition of 125. (Curi- ly enough, the Egerton-Williams Stu- where the plates are being printed, is hin walking distance of Havell's old dio, where they were first engraved.) o print the first edition of the *The ds of America*, Havell used a common hnique of the time, although one rarely ployed on the enormous scale or size as double elephant folio. Using Audu- 's watercolors as a guide, Havell en- ved the birds and backgrounds on large ny more than six square feet) copper es. The plates were then printed in ck ink, and colorists painted over each pression with watercolors. Although dubon was delighted with Havell's gravings, he often complained about the lity of the coloring. Indeed, anyone o has had a chance to compare two of nineteenth-century prints will proba- have noticed marked variations in or. Pressed for time and money, the col- sts sometimes cut corners, especially en Audubon was away selling subscrip- ns. Writing in his usual blunt manner, dubon brought his complaints to vell: "Do let me urge you more than r to pay the strictest attention to the louring for its is doubtless through their

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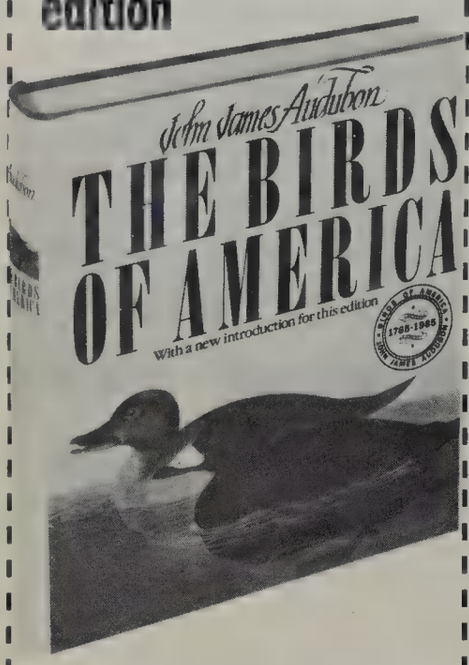

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Audubon's original watercolor of the Snowy Owl

The New-York Historical Society, N.

evident carelessness that the Work suffers so much at present." A few days after dispatching this letter, he received the proof of the Baltimore oriole and fired off another letter: "The hanging nests [are] no more like my drawing than a chimney sweep is to your beautiful wife." At one point he even had the colors bleached out of several prints.

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Alecto will sell the edition by subscription, and the Museum has agreed not to strike any additional prints from the six plates for general sale for at least fifty years. The royalties from the edition will endow a fund for natural history in Audubon's name.

Two proofs of the new prints, the *Wild Turkey* and the *Snowy Owl*, will be on display in a new exhibition opening April 18 in the Museum. Entitled "Audubon: ence into Art," this exhibition will su quently tour the country. The Museu new edition will also be featured in Da Attenborough's upcoming television umentary on Audubon, which will ai the United States on Wednesday, A 24, at 8:00 P.M. on the Arts and Entert ment Cable Channel.

Audubon once wrote to one of his s

At the American Museum

New Magazine for Children

The Museum has announced the publication of *Faces*, a new magazine that explores anthropology, archeology, and cultures of the world. Geared for children eight to fourteen years old, *Faces* includes short articles, games from around the world, puzzles, photographs, and tales and legends. Each issue is devoted to a single theme; among these are dragons in cultures around the world, myths and legends of the Hopi Indians, and African gold. *Faces* is published by Cobblestone Publishing in cooperation with the Museum. To subscribe, send $16.50 ($13.95 for Museum members) to *Faces*, 20 Grove Street, Peterborough, NH 03458.

Audubon Exhibition

A new exhibition on the great American naturalist John James Audubon will open on April 18 in the Naturemax Gallery. *Audubon: Science into Art* includes a wealth of material from the Museum's substantial holdings of Audubon iana—including some of Audubon's watercolors and oil paintings, original letters and manuscripts, bird specimens, palette and guns, and buckskins. Also on view will be two prints from the Museum's new edition of six plates from *The Birds of America*. After July 21, the exhibition will be presented at a number of other museums in the United States.

Man and Nature Lectures

In April, Nobel laureate Gerald Ed man will deliver the *1985 Mack Lip Man and Nature Lectures*. In a series five lectures entitled "The Sciences Recognition," Edelman will explore t evolution of life from simple-celled orga isms, the growth of an embryo from a f tilized egg to a functioning adult, and t most recent theories on the nature a function of the human mind. Edelma lectures will draw on his research on e bryonic development and the organiz tion of the higher brain functions.

All lectures will take place in the Au torium at 7:00 P.M. On April 8, the topic "Evolution: Adaptation and Organiz Complexity"; on April 10, "Developme tal Biology: Molecular Bases of Anim Form"; on April 12, "Immunology: Sele tion and Instruction"; on April 15, "Ne robiology: Categorization and Learning and on April 17, "The Grand Loop: Ev lution and Awareness." Tickets for the s ries are $10 for members, $20 for no members. Call the Membership Office (212) 873-1327 for more information.

Maya Exhibition

Maya: Treasures of an Ancient Civ lization, a major new exhibition of 27 Maya artifacts, opens in Gallery 3 April 26. Following its appearance at t Museum, it will travel to the Los Angel

David Attenborough

Arts & Entertainment Netwo

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ary means ever will raise for them-
es such a Monument as 'the Birds of
erica' . . . over their tomb!" With his
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not be surprised to learn that *The
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of the most famous and valuable
ks created in the New World.

Douglas J. Preston

nty Museum of Natural History, Au-
27–November 3, 1985; the Dallas
seum of Art, December 15, 1985–
ruary 16, 1986; the Royal Ontario
seum, Toronto, March 22–June 15,
6; the Nelson-Atkins Museum of Art,
sas City, July 19–September 7, 1986;
the Albuquerque Museum, Novem-
16, 1986–February 8, 1987.

ht of the Bumblebee

n Saturday, April 27, at 2:00 P.M., I
tori di New York will present *Choral
sic of Birds and Bees and Bugs*, a con-
in celebration of flying creatures. The
ings for these pieces span several cen-
es, various languages, and a number of
posers. The free program will take
e in the Kaufmann Theater.

estial Rhythms

On May 1 and 2, the Hayden Planetar-
will present concerts featuring elec-
ic music. Accompanied by an array of
rs and special effects, three Planetar-
musician-composers will play selec-
s from "Star Wars," "The Right
ff," Pachelbel's "Canon in D Major,"
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information call (212) 873-5714. Also
he Planetarium are *The Violent Uni-
se*, *Wonderful Sky*, and *Heavy Laser*.

mals Animals

The World of Animals, a family pro-
m for members only, will take place on
nday, April 14, at 11:00 A.M., and 1:00,
0, and 4:00 P.M. Naturalist Bill Robin-
will be joined by a number of live crea-
es, including a spiny hedgehog, a
hbaby, a hawk, an eagle, and a pere-
ne falcon. The program is free, but you
st register in advance. Call (212) 873-
7 for information.

dubon Program

On Wednesday, April 24, at 8:00 P.M.,
Arts and Entertainment Cable Net-
k will broadcast "Audubon." Written
narrated by David Attenborough, the
gram will focus on the creation of *The
ds of America*. A segment was filmed
he Museum, and coverage is given to
Museum's new edition of six plates
m *The Birds of America*.

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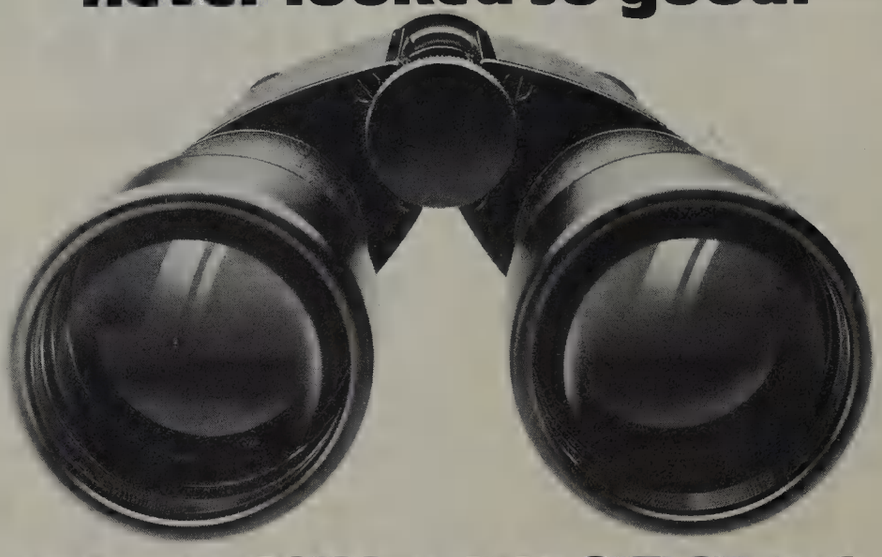

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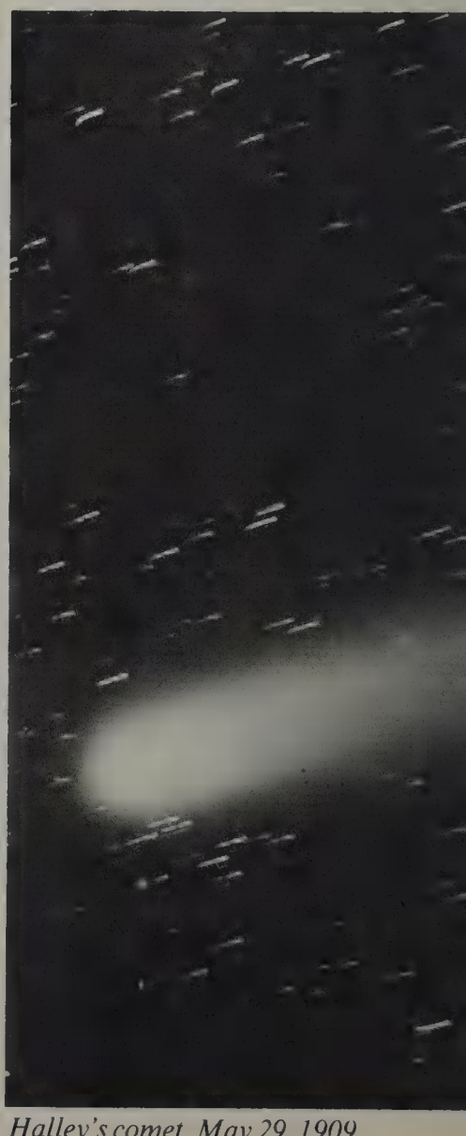
Surprises o Halley's Comet

Astronomers are puzzling over re changes in the comet's brightness

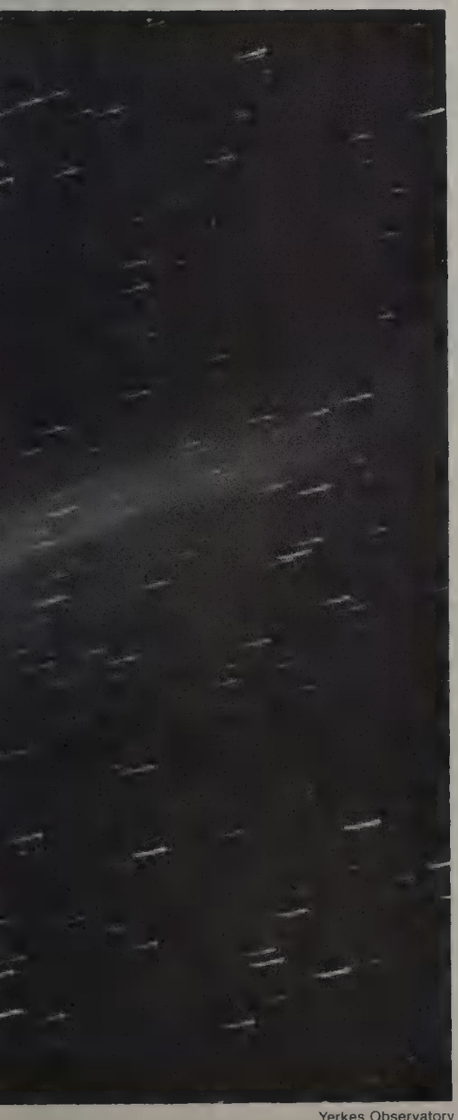
by Stephen P. Maran

As almost everyone knows by now, H ley's comet is on its way toward the and will sweep through the inner solar s tem next fall, winter, and spring, as it d every seventy-five to seventy-six ye The best viewing from the earth will pr ably occur near the time of new moon April 9, 1986, although the comet will



Halley's comet, May 29, 1909

ng by then. It will be at its brightest
ut February 9, 1986, when it makes its
est approach to the sun, but the earth's
tion will make viewing the comet from
ground impossible.
n April 1986, the comet will be deep in
southern sky, and the most favorable
tions for seeing it are likely to be in



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parts of Madagascar, Botswana, Peru, and Australia, according to predictions by Edward M. Brooks, an authoritative meteorologist and eclipse observer.

Although it is still very dim and distant, the comet has been under observation since October 16, 1982, when it was first spotted on its current approach toward the sun. The spotters, David Jewitt, now of the Massachusetts Institute of Technology in Cambridge, and G. Edward Danielson, of the California Institute of Technology in Pasadena, found Halley with the 200-inch telescope at Palomar Observatory. Theirs was the first sighting of the comet since 1911.

Jewitt, Danielson, and other astronomers, who have reobserved Halley on numerous occasions with advanced electronic detectors, found that it is undergoing major changes in brightness. The investigators are trying to account for those unexpected changes, but as yet there is no accepted explanation.

Besides monitoring brightness changes, astronomers have been trying to detect the comet's coma, or atmosphere. According to the so-called dirty iceball theory, the permanent body, or nucleus, of a comet is a rotating solid ball of frozen gas, interspersed with microscopic rock dust particles. As a comet approaches the sun, solar heat turns the frozen matter near the surface of the nucleus to gas, thus producing the coma. Then, when the comet's orbit takes it far away from the sun, the coma is expected to dissipate as its constituent gases stream out into space and are not replaced.

The nucleus of a comet shines by reflected sunlight. Accordingly, the spectrum of the nucleus is only the sun's spectrum and there is no direct evidence of the nucleus' composition. When a coma is present, however, astronomers can observe its spectrum and determine which gases are present and in what amounts. By timing when the coma first forms, investigators can determine when the nucleus begins to release significant amounts of gas. Then, by obtaining spectra of the coma at subsequent intervals, they can monitor how its chemical composition varies as the comet approaches and rounds the sun. From that information, they try to elucidate the processes that govern the interaction of a comet with solar radiation. That's why observers have been looking for signs that the coma has formed on Halley's present approach toward the sun. If Halley did have a coma on January 4, 1984, when Jewitt and Danielson again photographed it from Palomar, it was too faint to be detected. At that time, the comet was still 760 million miles from the

Investigators believed that the com Halley's comet had finally attained tectable proportions on September 1984, when the comet was about 577 lion miles from the sun. At least, th what two astronomers from the Univer of California at Berkeley reported. T announced then that they had found coma with the 158-inch telescope at Peak National Observatory in south Arizona. One of the Berkeley astr mers, Stanislav Djorgovski, noted, "" must be one of the most distant co ever detected from the ground." Abo month later, however, astronomers at University of Hawaii, in Honol scanned the comet with an 88-inch t scope with less success. One of them, M. Pasachoff of Williams College, Massachusetts, told me that they found no obvious sign of a coma. Perh a coma is a variable phenomenon t comes and goes until it becomes f formed when the comet is near the su perhaps Halley was still so faint in S tember and October of 1984 that even perienced observers could reasonably agree on what was or was not visible.

The unexpected brightness changes Halley's comet might be related to the fering results of the groups looking for

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ıa. One group apparently found it in tember, while another saw no hint of it October. A bright coma is obviously er to detect than a faint one; it is even sible that the changes in brightness are to the formation and dissipation of porary comas, resulting from bursts of emission from the nucleus. Thus, en Djorgovski detected the coma on tember 25, he and a Berkeley colgue found that the comet was 50 to 100 cent brighter than expected.

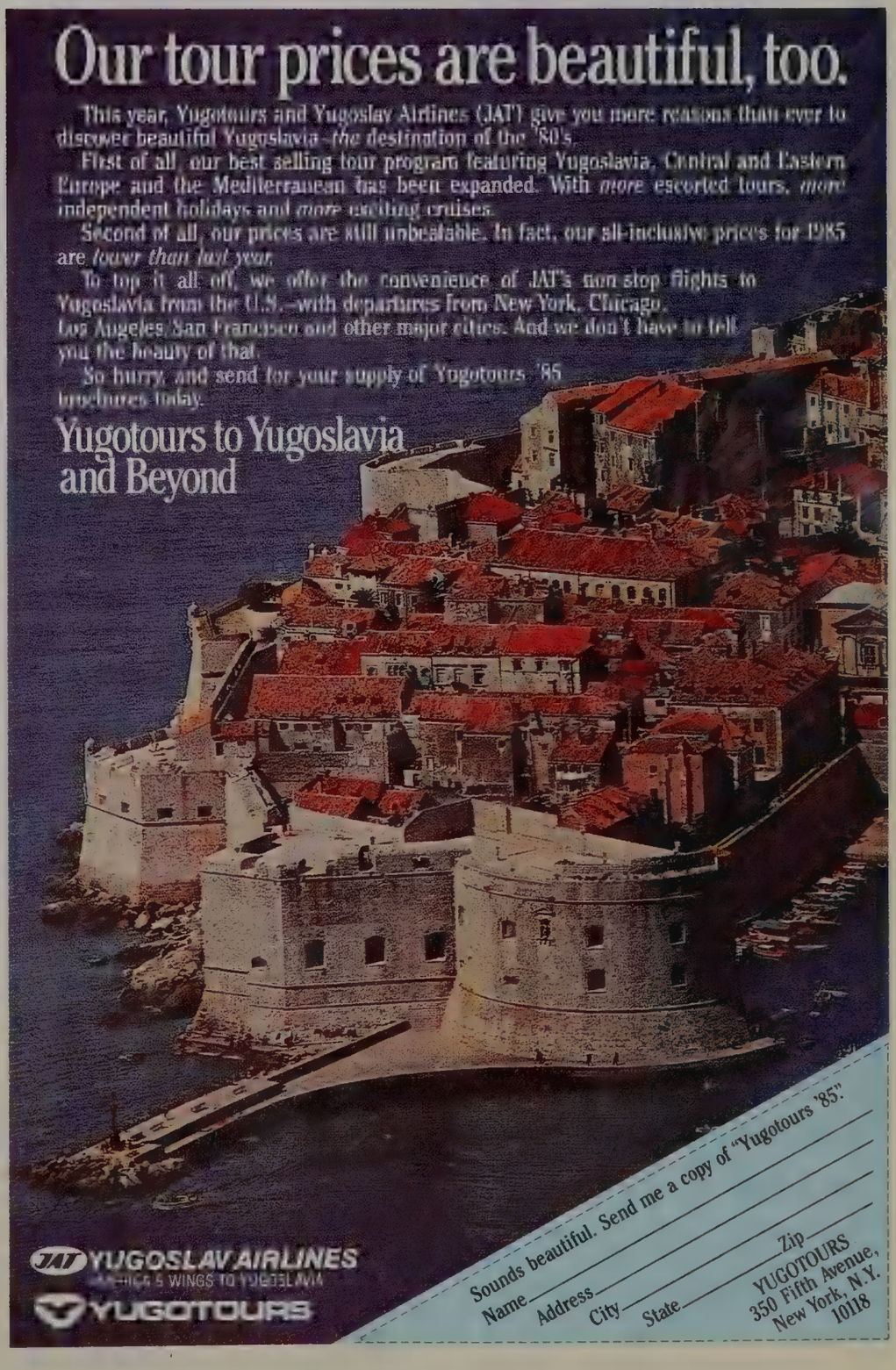
On the other hand, the unexplained ghtness changes of Halley's comet may e nothing at all to do with a coma. Inad, some astronomers propose that Hals recent brightness changes may be evnce of bright and dark areas on the net's nucleus.

f there is no coma—or at least not a ght, well-developed one—then the ghtness of the comet would depend on reflection of sunlight by the nucleus. If nucleus has unevenly distributed ght and dark areas, then as it rotates it uld reflect sunlight in varying amounts l would thus seem to brighten and fade iodically. If such is the case for Hal's comet, we might hope to determine rate at which its nucleus is turning by dying its brightness changes. Brights changes might also tell us about the pe of the nucleus. For example, a erical nucleus with a uniformly reflect surface (that is, no contrasting bright l dark areas) would not vary greatly in ghtness except in response to changes ts distance from the sun and the earth. t if Halley's nucleus were, say, oblong, n there might well be pronounced ghtness changes as it alternately sents its long and short sides toward the th, even if the nucleus surface is a unimly bright reflector.

Among the research groups that have en monitoring Halley is a team of six nch astronomers who observed the net with the 142-inch Canada-France-waii telescope on Mauna Kea during bruary 2–4, 1984, when Halley was out 739 million miles from the sun. ey reported detecting "rapid recurring reases" by up to about a factor of six in brightness of the comet. The increases med to recur at intervals of about enty-four hours and eighteen minutes, e or take twenty minutes. As one possi explanation, the French team sugsted that Halley's nucleus might have e very dark hemisphere, "like a tiny niature of the Saturnian satellite petus" (see "Iapetus, Saturn's Mysteris Moon," *Natural History*, October 84). The French measurements are difult to interpret because they are compatible with rotation rates as rapid as one turn per eight hours and six minutes and as slow as one turn per forty-eight to fifty-one hours. Furthermore, the French astronomers concluded that, rather than having a dark hemisphere, Halley's nucleus might be dark overall, but with a few large white regions.

Pronounced brightness changes in Halley have also been measured by astronomers at the European Southern Observatory on Cerro La Silla, in Chile, and by Jewitt and Danielson, at Palomar. A detailed analysis of many of these measurements by Zdenek Sekanina, an authority on comets and meteors at the Jet Propulsion Laboratory in Pasadena, led him to conclude that the rotation rate of Halley's nucleus is slower than one turn per day. He speculated that the large brightness changes may be due to the intermittent expulsion of electrically charged dust from the nucleus or to light reflecting from thin plates of ice on the nucleus. Such plates have been formed in laboratory experiments simulating a cometary environment. If present on the nucleus, the little plates would reflect sunlight as if they were mirrors, rather than in the manner of ordinary rough surfaces.

Further observations may help to determine the cause of Halley's brightness changes, but it seems to me that once the coma is fully formed, changes of the kind already observed may become less pronounced (if indeed they continue to occur)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and will be correspondingly more diffic to study from the earth. Observatio made from space might help solve t mystery.

Two Soviet interplanetary spacecra *Vega 1* and *Vega 2*, launched in Decemb 1984, are en route to Halley by way of t planet Venus. After dropping probes off Venus, they will continue toward t comet and pass it in March 1986, wh they will send photographs and other da including measurements of dust partic made with an American instrument, ba to Earth. This summer, the Europe Space Agency (ESA) and Japan will a launch spacecraft toward a March 19 rendezvous with Halley. One of the spacecraft, particularly the ESA prob Giotto, which is expected to approa Halley's nucleus most closely, may get t information necessary to explain t brightness changes. If the nucleus is bac out of round or if there are large dark a bright areas on the nucleus, as suggest by the French astronomers, then a pe scope-shaped electronic camera carri on Giotto has a good chance of phot graphing them.

Although NASA is not sending a pro to Halley's comet, it is actively involved studying Halley as well as other come NASA's International Cometary E plorer (ICE) will become the first probe pass through a comet when it reach Comet Giacobini-Zinner on Septemb 11, 1985. The Soviet and ESA spacecra controllers will be watching this eve with much interest, for if high-speed du particles from Giacobini-Zinner dama or destroy ICE, there would be obvio consequences for the targeting of the cra en route to Halley. (Halley is believed be a much dustier comet than Giacobi Zinner.) The foreign controllers mig then choose to steer their craft past Hall at greater distances than planned present. On the other hand, if ICE su cessfully penetrates Giacobini-Zinner tail, the measured data will compleme the studies planned for the Halley probe

In February 1986, when Halley brightest, viewing conditions on Earth w be poor, but as Halley nears the sun in la January 1986, NASA astronauts will dro a special Halley-observing satellite into o bit around the earth from the space shu tle *Challenger*. That satellite, called *Spa tan Halley*, will be programmed b physicists at the University of Colorado make spectroscopic observations of Ha ley's coma and tail in ultraviolet light fo about forty-eight hours. Afterward, *Cha lenger* will take the satellite back on boar for return to the ground. At the same tim continuing through March, the sun-ol

ing satellite *Solar Max*, which was re-ed in space by a shuttle crew in April '4, will monitor Halley with a spec-neter and a coronagraph, a device in-ded to photograph faint features de-e the glare from the bright solar disk. d although the comet may be near or ind the sun as seen from the earth, h is not the case from the vantage point he planet Venus. Accordingly, Halley be monitored by the U.S. spacecraft *neer Venus Orbiter*, which has been cling Venus since 1978.

When the Soviet, ESA, and Japanese bes visit Halley in March 1986, there be four trained astronomers among a w of six orbiting the earth in a U.S. ce shuttle. Two of them, drawn from ranks of full-time researchers rather n from the corps of astronauts, will op-te three telescopes equipped with so-sticated instrumentation and located in shuttle payload bay. Looking at live vision pictures from the payload, the cialists in the shuttle's cabin will aim telescopes at specific parts of Hal-s comet for spectroscopic, photo-phic, and polarization measurements; smaller cameras mounted with the escopes will take wide-angle photo-phs of Halley's tail.

While all of the above is under way, usands of astronomers and millions of er people will be trying to watch Halley m the ground. Except for those situated he best viewing locations in the South-Hemisphere in April 1986, most per-s will need information and perhaps in-uction on how to spot the comet, since it l not be a prominent sight from most ces. (This is a tricky subject. For exam-, in January 1986, with the comet in the thern sky, the best viewing locations l be cloud-free mountaintops in the rthern Hemisphere.)

f you are among the would-be Halley wers, and I hope you are, nearly every al planetarium, science museum, and lege astronomy department will have ormation available by the fall of 1985, hey do not have it already. Where view-conditions permit, such organizations, ng with local amateur astronomy clubs, y sponsor public viewing sessions. If u are not yet in touch with astronomy re-rce groups in your own region of the es just mentioned, now is the time: lley's comet will not come again until 61.

ephen P. Maran is a senior staff scien-in the Laboratory for Astronomy and lar Physics at NASA's Space Flight nter in Greenbelt, Maryland. The opin-s expressed here are his own.

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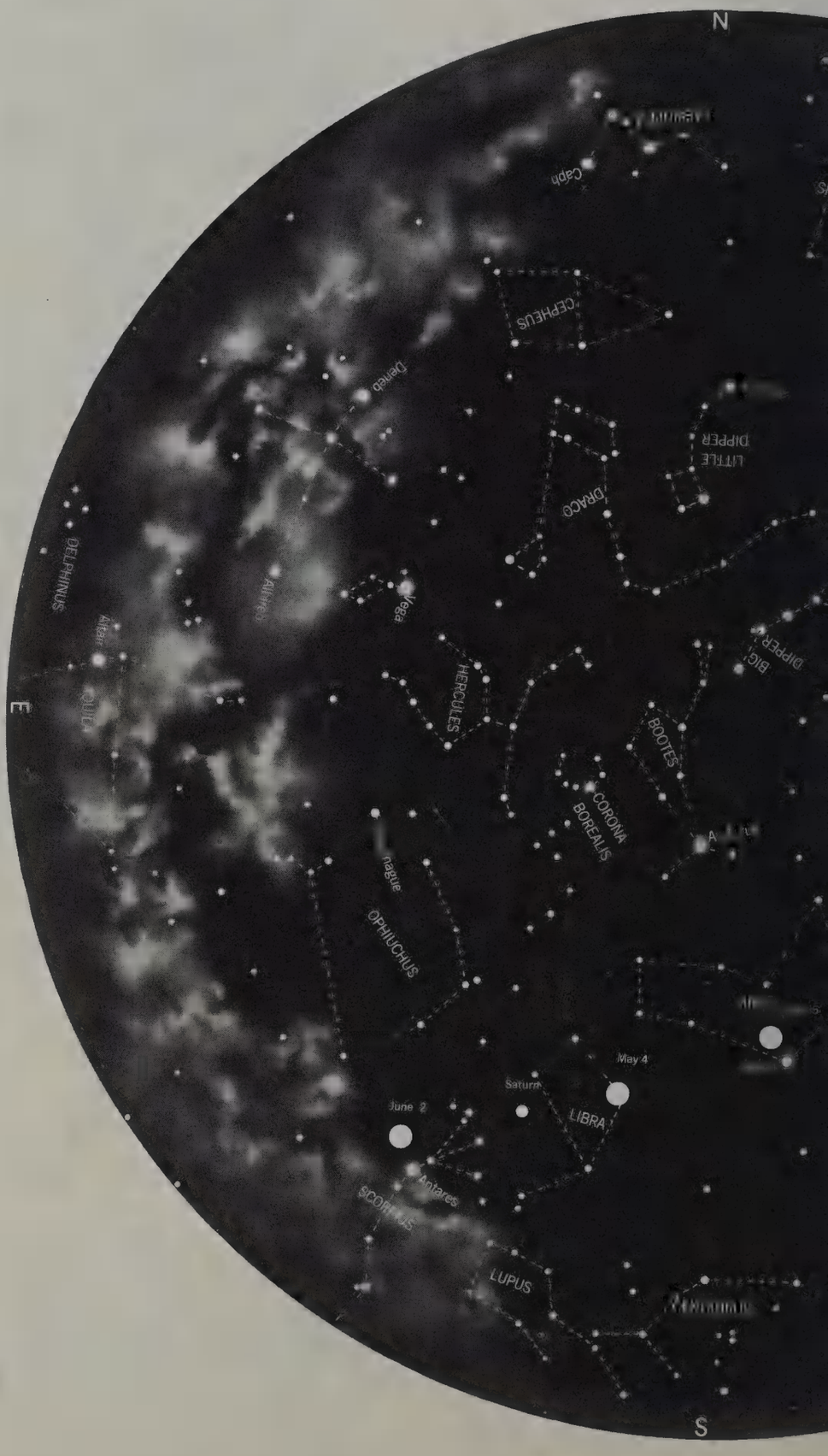
Stellar Early Risers

by Thomas D. Nicholson

Evening skies are barren of planets in April. Only Mars remains east of the sun (to its left at sunset), but it is dim and low in the early evening, as it moves from Aries into Taurus. There is an evening moon at the beginning of the month; during the last week it will help trace out the spring stars. Two morning planets, Saturn and Jupiter, will rise earlier night by night and spend much of the dark hours above the horizon. Saturn is up soon after 10:00 P.M., earlier at month's end, in Libra near the bright stars that form the head of the celestial scorpion. Jupiter, in Capricornus, rises about three hours past midnight on April 1, but two hours earlier at the end of the month. Both planets are up at dawn: Jupiter very bright in the southeast; Saturn to the west. Toward the end of April, Mercury and Venus make their presence known as morning stars, after passing between the earth and the sun early in the month and emerging from the sun's glare before sunrise. Mercury's morning appearance isn't good in the spring, but it may still be seen low in the east before



The spring Sky Map shows the sky for the months of April, May, and June from latitude 40° north at the evening hours given below. To use the map, hold it vertically in front of you with north (N) at the bottom, and match the lower half of the map with the stars you see when you face north. As you face in other directions, roll the map to bring the corresponding compass direction to the bottom of the map.

The stars move west continuously during the night. By morning (before dawn) stars on the western half of the map will have set, those on the eastern half will have moved into the west, and new stars (those of the fall evenings) will have risen in the east. The map represents the sky at about 2:00 A.M. on April 1; 1:00 A.M. on April 15; midnight on April 30; 11:00 P.M. on May 15; 10:00 P.M. on May 31; 9:00 P.M. on June 15; and 8:00 P.M. on June 30. Add one hour for daylight time. The map can be used for an hour or more before and after the times given.

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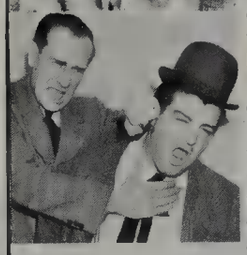

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dawn. Try to find Venus first; even though it is not placed much better than Mercury, its brightness makes it much easier to find. If you see it in late April, look carefully below it and you may find Mercury. The view of Venus will improve in May.

Events in the calendar below are given in local time unless otherwise indicated.

April 1: A waxing gibbous moon is well up by dusk (visible in the afternoon if skies are clear). Beneath it is Regulus, Leo's bright star. The circular group of dim stars in which the moon is nestled forms the Lion's head.

April 2: The moon is east (left) of Regulus, and fatter.

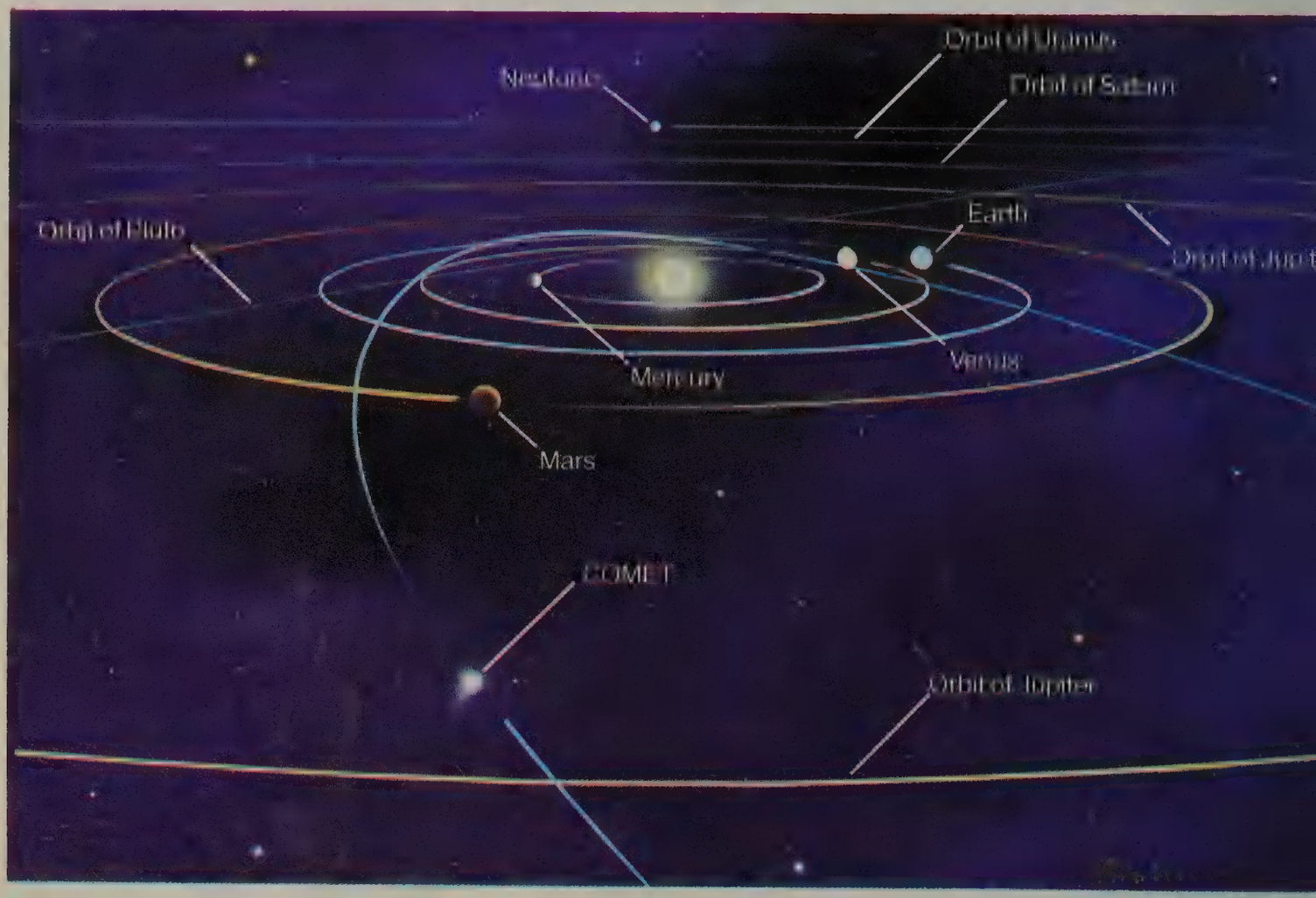
April 3: Venus and Mercury move in tandem between the earth and the sun (inferior conjunction), leaving the evening to become morning stars.

April 5: Full moon (at 6:32 A.M., EST) is in Virgo. Spica is the bright star to its left. Perigee moon (nearest the earth) comes just six hours past full and will surely fect tides tonight and tomorrow, ad strength to the full moon's spring Watch out for flooding in coastal areas pecially if the winds are strong and f the right direction.

April 6–7: The waning gibbous m slips into Libra, approaching Saturn, bright object to the east. On the nigh the 7th it passes below Saturn.

April 8: Moonrise isn't until after 1 P.M. The reddish star rising below

Halley's Comeback



In the beginning of April, as it races to perihelion (February 9, 1986), Halley's comet is 28.8 million miles closer to the sun than it was a month ago, but it is 22.3 million miles farther from the earth. (The earth and the comet are actually separating in April.) The earth's orbital motion takes it away from the comet until early May, then rapidly toward it again.

The illustration above depicts the solar system's inner planets and Halley's comet as they will appear on April 25, when the comet, racing along in its orbit at about 39,800 miles per hour, is slightly less than 400 million miles from the sun and 454 million miles from the earth. Its position is still somewhere between Jupiter's orbit, which it passed in January, and Mars's orbit, which it will pass in late November. Of course, the comet is nowhere near either planet at the time it moves past their orbital pa Because of its inclined orbit, Halley's comet is well below plane of the planetary system until November 1985, when its bit cuts through the plane from south to north. In April, i nearly 100 million miles south of the solar system's central pla

Note in the illustration that we have come in closer to the c tral solar system than our view in March. Now you can see comet's retrograde orbit (clockwise around the sun as viewe from above), which is unlike the easterly (counterclockwi movement of the earth and the other planets. Because they mo in opposing directions, the earth and Halley's comet will alt nate between approaching and receding from one another s eral times over the next year.

noon is Antares, in Scorpius. Saturn is to heir right and higher.

April 9–11: The waning gibbous moon pends the night in Sagittarius, rising after nidnight on the 9th and later the next two ights. Last quarter is at 11:41 P.M., EST, n the 11th.

April 13: Jupiter is the very bright ob-ect near the morning moon, from about :00 A.M. until dawn.

April 15: Mercury resumes its normal easterly) motion.

April 17: The moon is just below the ernal equinox about dawn, and Venus is bove and to its left. This may be the last norning view of the moon during this cy-le of phases and the first one of Venus as morning star this spring. To find Venus, ook after dawn to where the sunrise rightens the sky. The planet will improve n successive mornings (higher at each awn), but the morning moon is on the ay out.

April 19–20: Apogee moon (farthest om the earth) occurs at about noon, ST, on the 19th; new moon will be at 2:22 A.M., EST, on the 20th.

April 22: There are three events in to-ay's calendar. First, Venus ends its retro-rade motion and resumes a normal east-rly drift through the stars. It rises bright nd early this morning but it will be diffi-ult to observe. Second, the moon covers lars as it passes by the planet at 8:00 M., EST, but this is a daylight event for e southern Atlantic basin, where the oc-ultation takes place. Third, a young cres-ent moon makes its first appearance in is cycle of phases, in the west, setting at vilight. Look high in the east for the yrid meteor shower, which peaks about 00 A.M., producing some fifteen meteors n hour.

April 24: The crescent moon is easier to e tonight, midway between Aldebaran n Taurus), which is below and to its left, nd Pollux and Castor, above and to its ght. Moonset occurs at about 11:00 P.M.

April 25–26: The moon is in Gemini oth nights as it grows to first-quarter hase (half moon). On the 26th it forms a reesome with the twin stars Pollux and astor.

April 27: First-quarter moon (at 11:25 M., EST) is in Cancer. After midnight night (the 28th), clocks should be set ead one hour in communities that ad-st to daylight saving time.

April 28–29: The gibbous moon moves o Leo. Watch it slide toward the star egulus during the night of the 28th. By e night of the 29th, it will be past Regu-s, moving away from it to the left.

April 30: The moon moves from Leo o Virgo.

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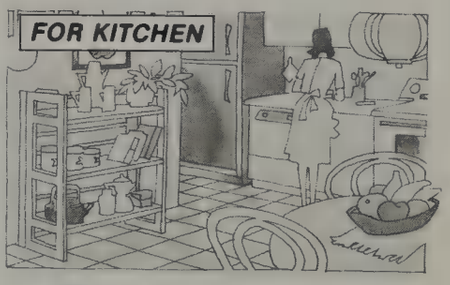

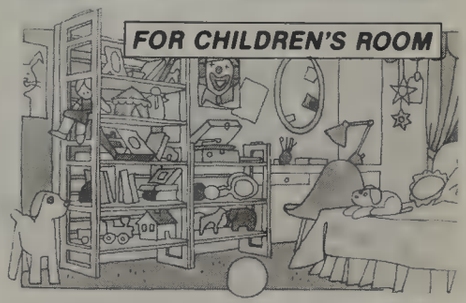

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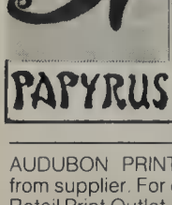

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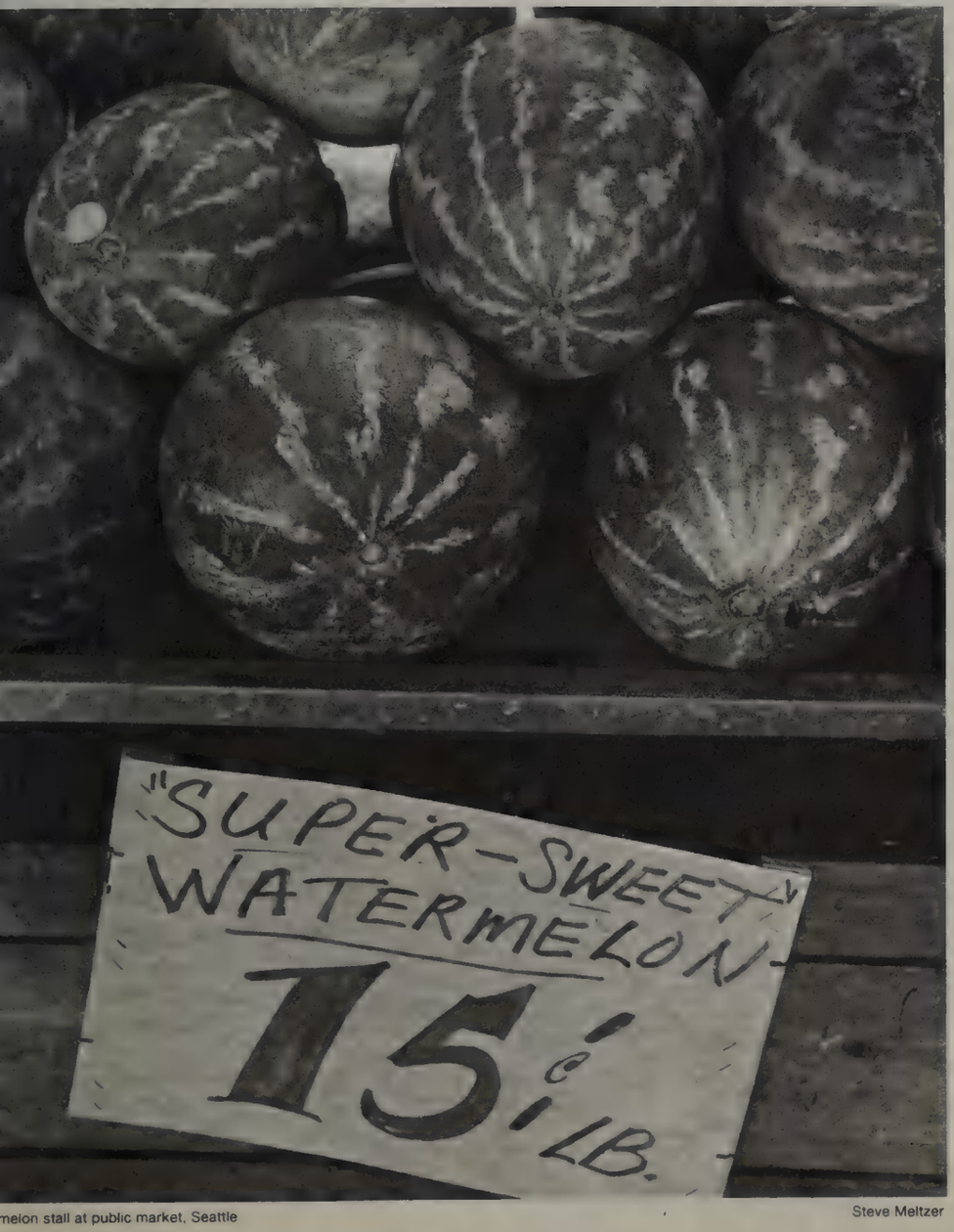

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Friends and Anemones

Clownfish, happy looking fish of the genus *Amphiprion,* live symbiotically with deadly stinging sea anemones. Benefits include protection from predators and food (scraps of fish or algae). In return, clownfish occasionally feed their anemone by shoving food captured in the surrounding area into their patrons' tentacles and perform guard duty (clownfish are as aggressive as guard dogs in driving off intruders, even though they don't have much of a bark or bite). Researchers agree that anemones tolerate clownfish because they don't recognize the latter's mucus layer (the slimy layer covering the outer surface of all fish) as "foreign." But how do clownfish disguise themselves?

On this, there is no agreement. Schlichter, a German scientist, thinks clownfish coat themselves with the anemone's own mucus by rubbing up against anemones during an "acclimation period." Lubbock, an Englishman, thinks clownfish mucus may be "inert," meaning that without any change at all it would trigger no response from anemones. But Dick Mariscal, who works out of Florida State University, thinks clownfish manufacture *new* mucus (the right stuff) during acclimation.

To prove it, Mariscal and Randy Brooks (now of Auburn University) cut rubber bands into one-inch strips, then glued them to the base of a petri dish until they had created something resembling an anemone. They put some *Amphiprion clarkii* into a tank with the dummy, left them there several days, and then transferred them into another tank with a real anemone. They wanted to see if the experiment affected acclimation time, the time it takes before a clownfish no longer gets stung. As Brooks and Mariscal later reported, "the average acclimation time to a real anemone was 156.9 minutes, compared with 21.7 minutes for those fish previously allowed to orient to the surrogate."

What had happened to the fish that lived among the rubber bands? They certainly hadn't picked up any anemone mucus (Schlichter), and if their mucus was inert (Lubbock), living with the fake wouldn't have changed anything. Mariscal and Brooks believe the experimental clownfish may have adjusted faster because they had already gone through most of the basic biochemical change that enables them to cohabit with anemones.

Photographer Jeff Rotman has no opinion on such slimy matters. He knows only that clownfish are best photographed near sundown, when they are settling in for the night. It was near that hour when he waded into the Red Sea in a wetsuit to get this shot.—*D.W.*

Photograph by Jeff Rotman

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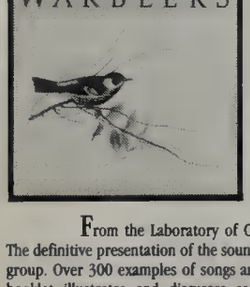

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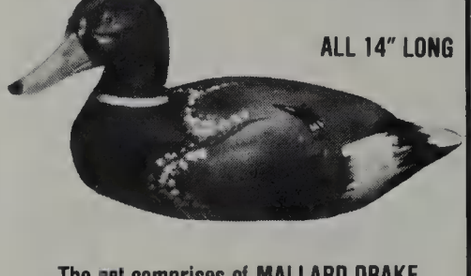

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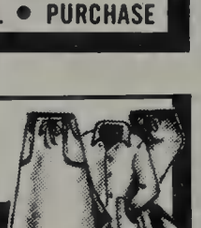

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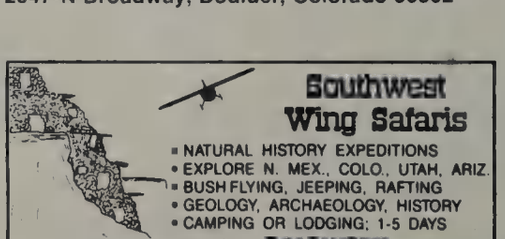

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Additional Reading

Maya (p. 42)

There are quite a few good books ab the Maya, and many are geared to a academic audience. For example, *Mysterious Maya,* by George E. St and Gene E. Stuart (Washington, D National Geographic Society, 1977), i up-to-date account of Maya civiliza enhanced by many fine pictures. Pat Culbert's *The Lost Civilization* (N York: Harper and Row, 1974) prov concise coverage of the Classic per while Charles Gallenkamp's *Maya* (N York: Penguin Books, 1981) covers whole of the civilization. Norman H mond's *Ancient Maya Civilization* (N Brunswick: Rutgers University Pr 1982) explores the empire's flowe and fall, its social structure, politics, art. According to John S. Henderson, *World of the Ancient Maya* (Ithaca: nell University Press, 1981) is "a surve the Maya cultural tradition: an introd tion to the societies that make it up an exploration of their contrasts, connecti and linked historical development."

Audubon (pp. 88, 94)

Alexander B. Adams's *John James dubon* (New York: G.P. Putnam's S 1966) is a well-researched biography the famed artist-naturalist. John Chan lor, a British antiquarian book dealer, wrote a popular biography of Audu (see *Audubon,* New York: Viking Pr 1978), made special, in part, because had access to materials in Europe aren't usually seen by the public. A Elizabeth Ford edited *The Bird Biog phies of John James Audubon* (N York: Macmillan, 1957), in which wrote about his subjects. F.H. Herri *Audubon the Naturalist,* the first m study of Audubon, was reprinted by ver in 1968. Dover also reprinted, in 19 Maria R. Audubon's version of her gra father's diaries, *Audubon and His Jo nals.* Using Audubon's writings as t guide, Mary Durant and Michael H wood—both talented writers—set ou retrace his journeys across America. T describe their adventures in *On the R With John James Audubon* (New Y Dodd, Mead and Co., 1984).

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The mintage is strictly limited to a maximum of 200,000 worldwide – or the deadline of December 15, 1985 – whichever comes first.

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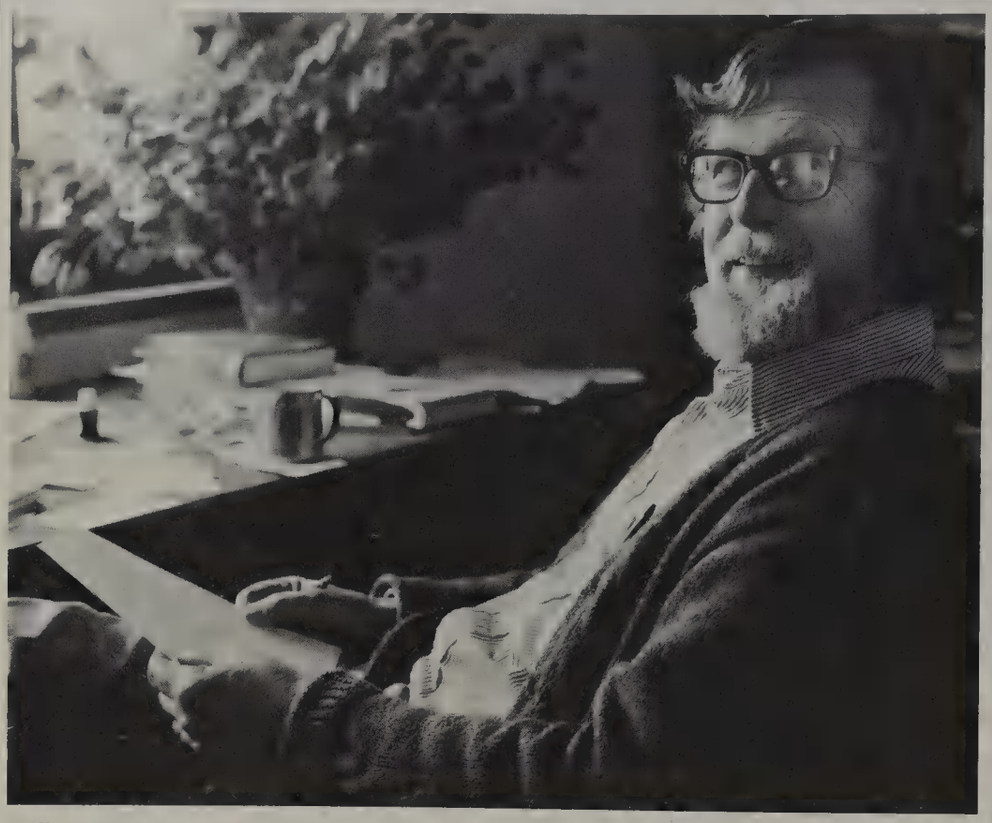
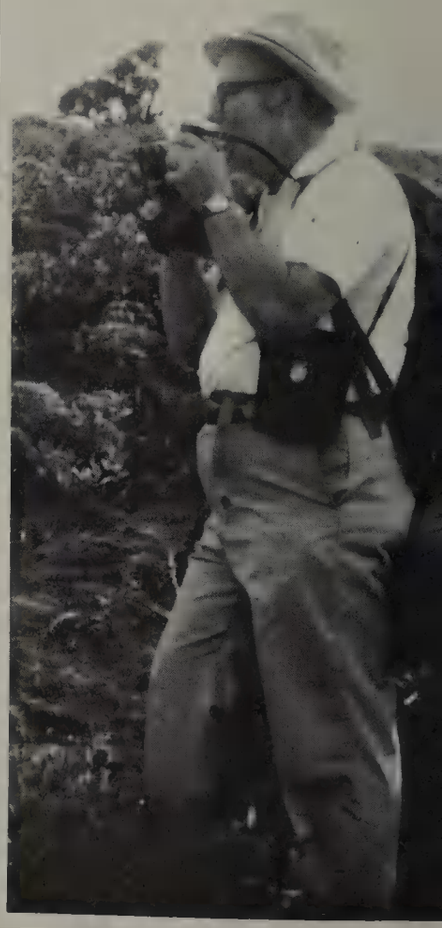


T. Patrick Culbert (page 42) has taken a lively interest in the recent breakthroughs in deciphering Maya hieroglyphs, which may help solve the mysteries of Classic Maya civilization. Culbert's major fieldwork has been at the lowland site of Tikal, in Guatemala. He is currently preparing a monograph detailing all the ceramics recovered there during fourteen years of excavation. He is also researching the ecological and demographic factors involved in the collapse of Maya civilization. After college, Culbert was a chemical researcher, but his interest in archeology led him to graduate studies in anthropology. He is now a professor of anthropology at the University of Arizona.

In studying the development of early American natural history and art, **Phillip D. Thomas** (page 94) considered Audubon's life and continuing popularity a logical focus for investigation. From 1981 to 1984, while living in Alaska, Thomas became interested in the role played by polar naturalists in describing the flora, fauna, and resources of arctic regions. He collects books and prints on the history of exploration and natural history illustration and enjoys building models of ships used by explorers. Other hobbies include such outdoor activities as fly-fishing, backpacking, and kayaking. A professor of history at Wichita State University, Thomas is dean of the university's Fairmount College of Liberal Arts and Sciences.

Kenneth C. Parkes (page 88) pu research in a range of topics, inclu the systematics and distribution of b plumage variations, molting, metho determining the age and sex of live b and hybridization. His fieldwork taken him around the United States to the Philippines, Argentina, and M ico. An admirer of bird art since he w child, Parkes wrote his master's thes color illustration of North Amer birds and has been on a jury for two art shows. He has long been intrigue the possibility that some unident birds depicted by Audubon were brids. In 1953, Parkes joined the sta the Carnegie Museum of Natural tory in Pittsburgh. He is now the m um's curator of birds and chief cur of life sciences.



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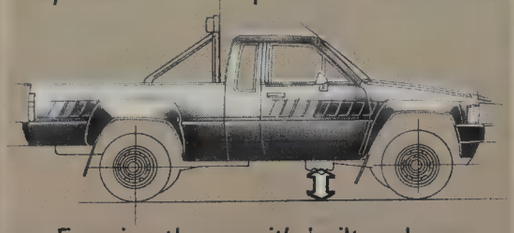

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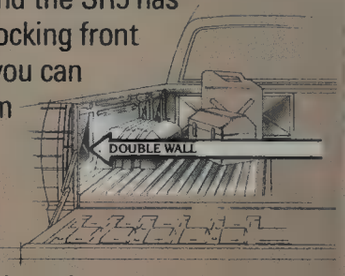

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ATURAL HISTORY *(ISSN 0028-0712) is*
ublished monthly by the American
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Vest at 79th Street, New York, N.Y. 10024.
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Cover: *Harsh conditions warped this bristlecone pine but also helped it live for thousands of years in California's White Mountains. Photograph by Peter Kresan. Story on page 38.*

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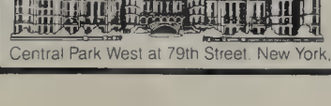

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own child's performance, parents also comment favorably to other moms and dads whose children have done well. Parents sit in silent embarrassment or make audible excuses when their children don't match or better their former best times.

American children are motivated to keep on swimming because they know that even if they don't achieve a new time in one event that day, they might better their time in another. Because they are allowed to swim in as many events as they have A times (for an A meet) or B times (for a B meet), most swimmers usually have something to be happy about when they get home.

An American swimming meet closely mirrors the larger society in that most people have good and bad moments, strong and weak performances, and despite disappointments, generally find rewards. Swimming is a particularly appropriate sport for a competitive, achievement-oriented society in which lines of social class are not clearly and rigidly drawn. Status within the American swimmer's world is like the form of social organization that anthropologists call the chiefdom, common a century ago in the Polynesian islands. In the chiefdom, slight gradations in prestige and power, rather than demarcated social classes, meant that everyone had a distinctive social status, just a bit higher or lower than anyone else's. A swimmer's unique status is the end result of a complex scoring process that takes into account a series of constantly changing times in different events. Like a Polynesian, every swimmer has a social status slightly different from everyone else's.

Time, then, is the basis of social status in American swimming. Public recognition of excellent times is, in itself, a potent reward. The more tangible prizes—medals and ribbons—go to only a small number of finalists (normally six, eight, or twelve), but everyone has a best time.

Since precious commodities usually have guardians, the swimmer's world has guardians of time (for example, parents armed with the most modern stopwatches). Even when electronic timing pads are used, each lane always has two human timers. There are also finish judges to determine finish order in close races and, for important meets, winning-lane timers. At the end of each heat, times are written on cards, which are used to determine and list finish order, official times, and winners. The results of each race are posted one by one in the halls of the building (usually a high school) where the meet takes place. By consulting these sheets, parents can compare their children's times with previous bests and with those of other swimmers. In this way the adu members of the society monitor wheth their young are keeping up with the peers and whether they are betteri themselves in terms of the values emph sized in American culture, including ind vidual achievement and hard work.

Swimmers' times—these public, pr cious symbols of achievement—a tended, guarded, enshrined in print, a transmitted from local to state to nation levels, where they are used to establi rankings. The most important source of i formation about times and nation rankings is the monthly magazine *Swi ming World*. *Swimming World* also pu lishes results of meets held throughout t

The annual index for
NATURAL HISTORY, VOLUME 93
(January through December 1984)
may be obtained by writing to:

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Natural History
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country, and sells a popular T-shirt, pr claiming "I made it in *Swimming World* an achievement that confers considerab prestige among fellow swimmers. The pa ticularly American character of the swi mer's world just described emerges cr tal clear when we consider the same sp in Brazil.

Before enrolling my son in a compe tive swim program in Rio de Janeiro 1983, I accepted the above procedure part of swimming per se—not as an illu tration of distinctive American cultu values. Even though I am accustomed comparing American institutions and b havior with those of other cultures, I h not thought much about how swim pr grams might be run differently elsewhe or what the meets might tell me about d ferent values and traditions. But striki differences between Brazilian and Ame can swimming were soon apparent. Fir Brazilian swim teams are associated w private, money-making professional clu such as the Fluminense Football (socc Club, for which my son swam. Most of t soccer clubs that battle for city, state, a national championships have divisions amateur sports, which manage swimmi gymnastics, and other competitive pr grams for children.

The clubs are commercial organiz tions, rather than the high school, colle age-group, and sports-club teams th dominate competitive swimming in t United States. It was as though my s were swimming for the Detroit Tige

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One of the tasks of the vice-president for amateur sports of a Brazilian club is to find rich sponsors, businesses or individuals, national or foreign, for the swim team. The soccer rivalry between such teams as Fluminense, Flamengo, and Vasco spills over into amateur sports. In Rio de Janeiro, swimmers and gymnasts play their own small parts in an ongoing battle for sports supremacy, and the system is similar in other Brazilian cities.

Daily practices are held in the Olympic-sized pools of the different clubs, and the competition is stiffer in a city of eight million than in the Detroit metropolitan area. Many Brazilian national champion age-group swimmers live in Rio, and their times (at least through the early teens) are comparable to those of top American swimmers. Cutoffs are much more stringent, however, and there are fewer meets—which means that swimmers lack opportunities to better their times and to gain experience.

Compared with the United States, Brazilian meets are badly organized. In the United States, meets are planned a year in advance; in Brazil, coaches often don't know until a day or two before the meet where it will be held, and sites are frequently changed at the last minute—for example, from a convenient pool a few blocks away to a suburb requiring an hour's drive. Cariocas (residents of Rio de Janeiro) are accustomed to associating with family and friends, but not with such strangers as the parents of their children's colleagues. There is no tradition of car pooling, and swimmers frequently miss meets because of last-minute changes. For American swimmers, to miss a meet is practically unheard of; mild illnesses or relatives' birthday parties are not acceptable excuses for letting down one's teammates. If one is scheduled to swim a relay, to miss a meet is considered especially unfair to other team members.

American swim meets almost always have relays—freestyle and medley (backstroke, breast stroke, butterfly, and freestyle, or crawl). Brazilian meets, however, rarely include relays; only one of the half dozen meets I attended in Rio had them. Perhaps relays are almost always a part of American meets because they embody key American values so well. The free relay is based on pure speed; it is the fastest of the races because everyone swims the fastest stroke, the crawl, normally called "the free."

The medley relay tests speed through specialization; each of four specialized swimmers tries for a best time to bring his or her team in first. It shows specialized individuals working rapidly together, like an efficient industrial or managerial team. Making the relay through a best time is a valued achievement. In relays, the win is more important than in individual events. Since relay members can change from week to week, swimmers have a less accurate recollection of relay times than personal ones. In these events, swimming celebrates certain American values: winning organization, competition through speed, efficiency, and specialization with other, similar groups. These values have spread out from the American economy to the larger society and are well represented in competitive swimming. In Brazil, the absence of relays helps focus attention on the individual win.

Even more noteworthy, however, than capricious meet planning and the absence of relays is the treatment of time in Brazilian swimming. In the United States, times are recorded electronically, as well as by people with stopwatches, and are publicly posted. In Brazil, however, times are not published in the mimeographed meet program. The swimmers' names and club affiliations are listed for each event, but their times are not. At first I supposed that, as in the United States, names were listed in an order established by prior best times and that the fastest swimmers swam in the last heat. After observing the results of several races in different meets, I learned this was not the case. Swimmers in the first or second heat were as likely to win as those in the last one.

Since times are not listed, parents and swimmers can concentrate only on who wins, not on who betters former times, which means that, rather than several possible winners, each event has only one. Public recognition of improvement—a key reward and powerful reason to keep on swimming—is missing. Nor are times publicly posted after each race. They are announced by loudspeaker after finish order is determined, beginning with the slowest swimmer and laboriously moving up to the winner—sometimes through twenty or thirty names. In this way parents and swimmers are reminded, not that many swimmers have improved, but that there are twenty times as many losers as winners.

Another feature of the Brazilian meet illustrates different cultural values about time. Where were the many guardians of time? I saw no attentive parents with stopwatches; there were no frantic winning-lane timers. Each lane had a single timer—even when the electronic pads weren't working. And, since timers often chatted as swimmers raced home, times were occasionally lost, an unheard-of occurrence in USS swimming. Times are not gathered, tended, and cherished as in t United States. This is one of many sy bolic statements in the swimmer's wo of the different values attached to time the cultures of the two Western giants.

Brazilian coaches do keep track of th swimmers' times, which they use to det mine who will swim what events in t next meet. But in contrast to USS swi ming, in which kids are normally enter in all races for which they have made c off times, in Brazil they are limited three of four races. This further reduc their opportunities for meet experience

Why are there so few opportunities swim competitively in Brazil? One reas is the absence of public school, partic larly high school, athletic programs. A other is the reduced level of parental volvement in organizing and runni meets, compared with that in the Unit States. There are simply too few volu teers to provide the needed chances compete, particularly in a city of eig million where thousands of young peo train as swimmers.

The pattern of stiff cutoffs and stricted competition is persistent and h unfortunate consequences for Brazil in ternational competition. For example, t Brazilian Olympic Committee did n send female swimmers to Los Angeles 1984 because none had made arbitrar established cutoffs. This excluded a Sou American record holder, while swimm with no better times were attending t Olympics as representatives of oth South American countries. The attitu was that only swimmers who had ma the cutoffs had any chance to place in L Angeles. No one imagined that the pov of Olympic excitement might spur swi mers to extraordinary efforts. During te vision coverage of the 1984 South Ame can Championships, held in Rio, I w aghast to hear commentators downgra chances that any Brazilian other than cardo Prado might win a medal. M than once I heard this comment abou new champion: "He doesn't have a char to win at Los Angeles because his ti isn't good enough"—as though it cou never get better.

American coverage, in contrast, do on unexpected results, showing adheren to an American sports credo: "It's not o till it's over." In Brazil, the credo seems be "It's over before it's begun."

Winning, of course, is an import American cultural value, and this is p ticularly true for college and professio team sports like football, basketball, a baseball. Football coaches are fond making such comments as "Winning is a good thing; it's the only thing" a

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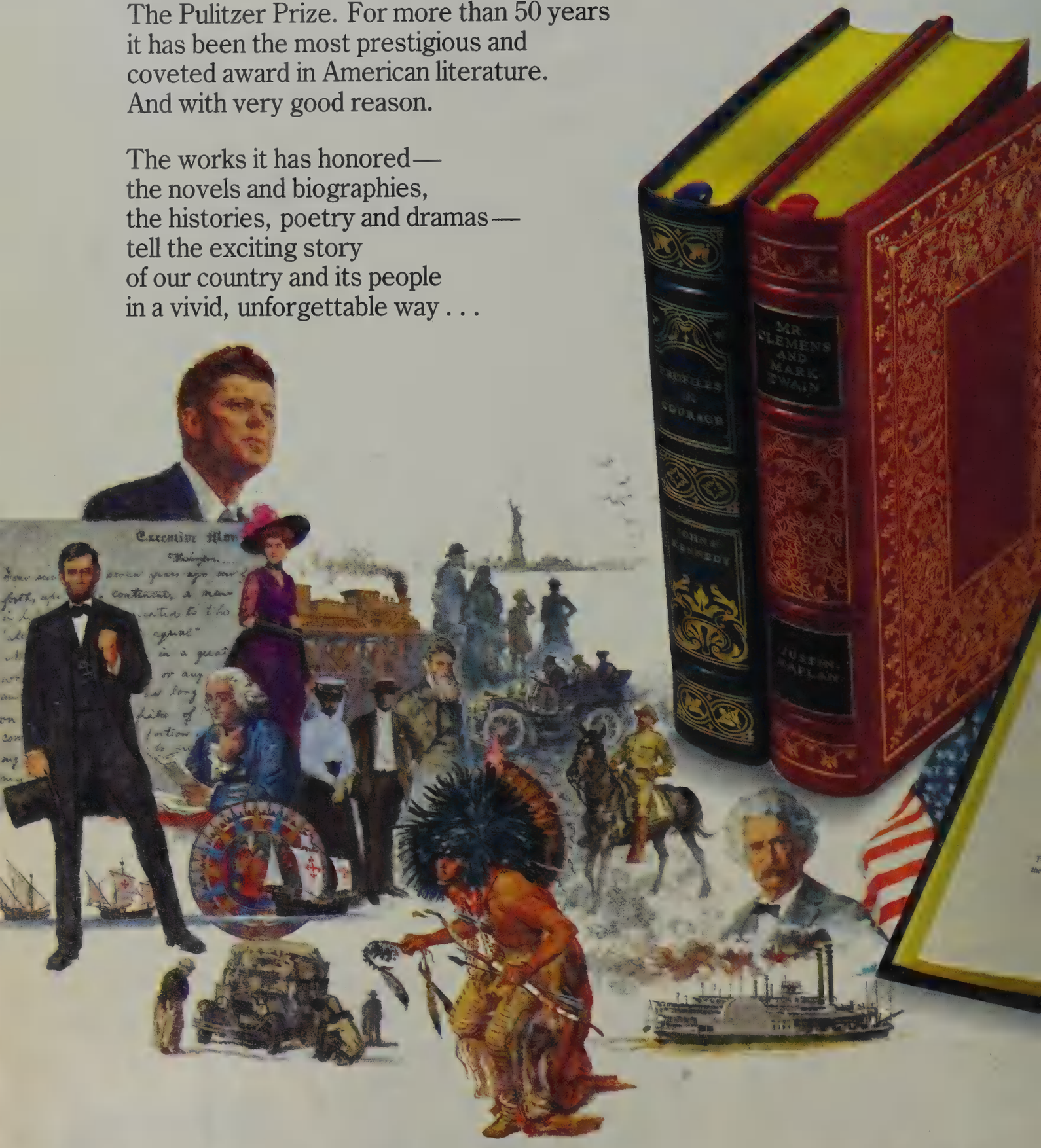

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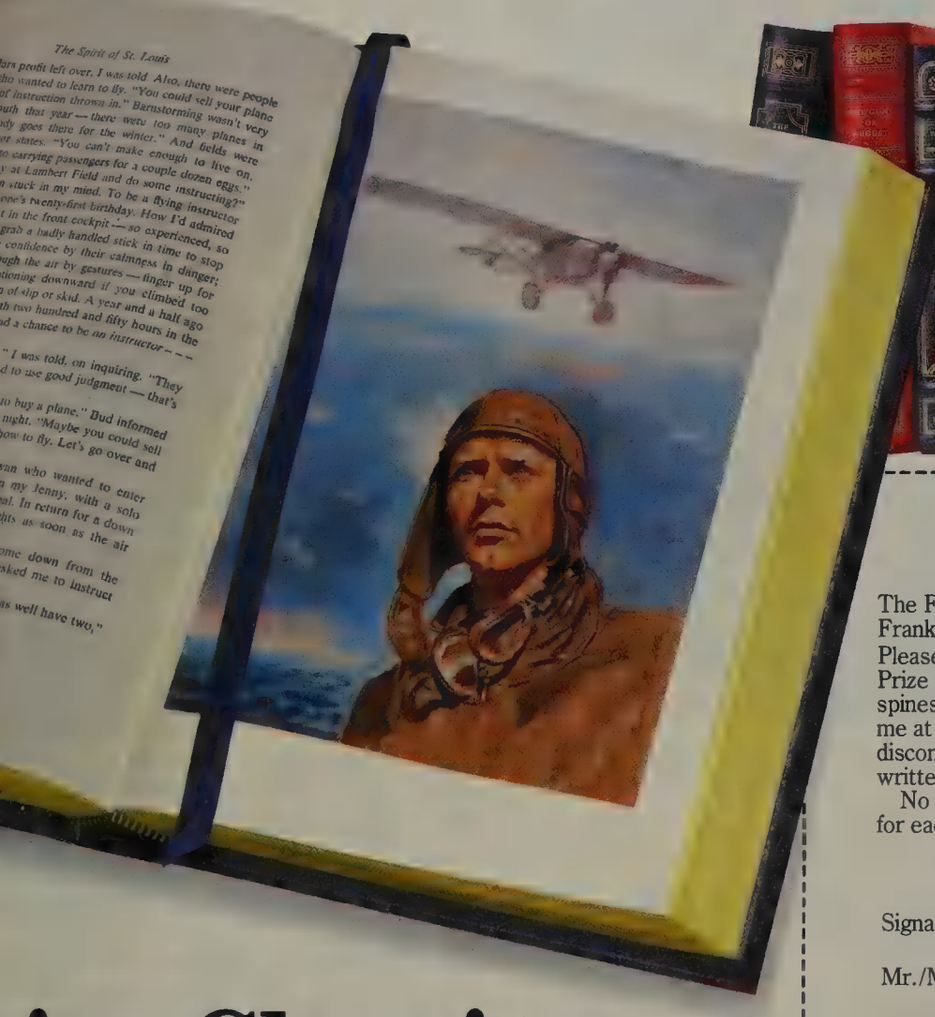

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"Show me a good loser and I'll show you a loser." For sports such as running and swimming, however, in which the focus is on the individual, American culture also recognizes and admires moral victories, personal bests, comeback athletes, and special Olympics, and commends those who run good races without finishing first. In amateur sports, personal improvement can be as important as winning.

Americans have been told so many times that their culture overemphasizes winning that they may find it hard to believe that Brazilians seem to value winning even more. Prior to the 1984 Summer Olympics, swimmer Ricardo Prado (instead of the eventual Brazilian gold medalist, Joaquim Cruz) was touted by the media as Brazil's most likely gold medal winner (he was a silver medalist). Prado had won 200- and 400-meter individual medley (IM) events in the 1983 Pan American Games and, until 1984, held the world record for the 400 IM. Commenting on his massive press coverage, Prado observed that only winning athletes were noticed in Brazil—only number ones, never number twos. He blasted the press for formerly neglecting his achievements and those of other Brazilian swimmers who were not, or not yet, world record holders.

Perhaps Brazilians value winning
much because it is so rare. In USS swi
ming, the focus on times means there a
always multiple winners. This may be t
key to the relationship of swimming to cu
tural values. In American society, whe
poverty is less pervasive, resources mo
abundant, social classes less marke
opportunities for achievement more n
merous, and individual social mobili
easier than in Brazil, there can be multip
winners. Brazilian society is more stra
fied; a much smaller middle class and eli
group makes up at most 30 percent of t
population. Brazilian swimming echo
lessons from the larger society: victori
are scarce and reserved for the few.

But there is another dimension to t
relationship between competitive swi
ming and society. Even in the Unit
States the opportunity to swim compe
tively is limited, generally to people of t
middle class and above. To swim serious
in America requires money, time, and p
rental involvement. American childr
begin swimming competitively for spo
clubs or country clubs, which have me
bership fees. Success in summer swi
ming may then lead them to join Y or US
programs, for winter competition. T
United States is an automobile-orient
culture. Cars and parents' time are nec
sary to drive to practices and meets. Du
ing Michigan winters, in order to arrive
distant meets for 8:00 A.M. warmups, m
son and I have sometimes spent the nig
in a motel. Swimmers' parents ha
money to spend on gas, food, lodging, a
club memberships. Children whose p
ents can afford to belong to clubs are mo
likely to get interested in swimming in t
first place.

In Brazil the situation is somewhat d
ferent. Public transportation is better
Brazilian cities than in most parts of t
United States. There is less resident
segregation of rich and poor, black a
white. Given the dense urban populatio
and that the major soccer clubs—a
therefore their swimming pools—are
cated right in the city, poor kids, includi
black children, can work out as swi
team members almost as easily as childr
from middle-class families. As a result,
contrast to the United States, where it
rare to see a black swimmer at a US
meet or in a state championship, swi
mers with dark skins and fast times a
present at virtually any carioca swimmi
meet.

Some Americans think that blacks a
whites excel in particular sports becau
of biological and physiological diff
ences, but Brazil, which has proportio
ately as many blacks as the United Stat

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monstrates that sports abilities reflect lture rather than biology. When blacks ve opportunities to do well in swimming, soccer, or tennis, they are physically pable of doing as well as whites. In hools, parks, and city playgrounds in the nited States, blacks have access to basell diamonds, basketball courts, football lds, and tracks. However, because of restricted economic opportunities, black milies have traditionally lacked the resurces to invest in hockey or ski equipent or join clubs with tennis courts and vimming pools. But as Brazilian swimming demonstrates, when these opportunties are available, blacks do well.

Here then is a different way in which e swimmer's world provides a microsm of the surrounding culture. Despite e emphasis in the United States on the ssibility of rising through hard work and dividual achievement, in swimming, as society, success is easiest for those who e better off to begin with.

What can we conclude about the differt cultural models for competitive swimming? Perhaps the more relaxed approach swimming encountered in Brazil rects a culture in which there is less emasis on time, measurement, comparin, and achievement. Brazilians may en experience fewer stresses and be happer because they live in a less competive, less achievement-oriented society. Whatever the case, one thing is eminently ear: the United States is a better training ound than Brazil for international comtitive swimming. As we know from ars of Olympic games and a glance at day's world records, the countries that best at swimming are the United ates, East Germany, and the Soviet nion. State support of Soviet and East erman swimmers is a powerful incentive r talented young people in those counes. Other nations that do well in internaonal competition—Australia, Canada, reat Britain, the Netherlands—are ore like the United States than Brazil in eir cultural backgrounds and current soeconomic conditions.

Despite pride in country, Brazilian vimmers know that it wasn't accidental at the South American giant could mange only one medal while its North Ameri n counterpart was winning thirty-four. ecognizing this, most of the Brazilian en who swam in the 1984 Olympics, inuding silver-medalist Ricardo Prado, are w training in the United States.

onrad Phillip Kottak, a cultural anropologist, is a professor of anthropoly at the University of Michigan in Ann rbor.

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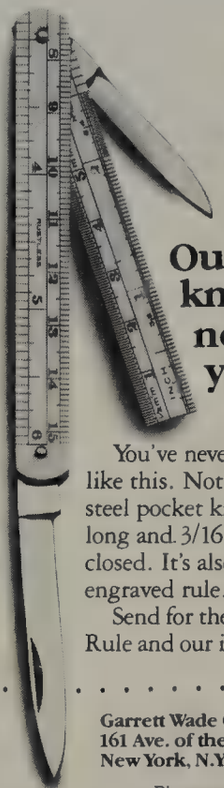

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Red Wings in the Sunset

Scientists, and artists, can be led painfully astray by the single-minded pursuit of an idea

by Stephen Jay Gould

Teddy Roosevelt borrowed an African proverb to construct his motto: Speak softly, but carry a big stick. In 1912, a critic turned Roosevelt's phrase against him, castigating the old Roughrider for trying to demolish an opponent by rhetoric alone: "Ridicule is a powerful weapon and the temptation to use it unsparingly is a strong one. . . . Even if we don't agree with him [Roosevelt's opponent], it is not necessary either to cut him into little pieces or to break every bone in his body with the 'big stick.' "

This criticism appeared in the midst of Roosevelt's presidential campaign (when he split the Republican party by trying to wrest the nomination from William Howard Taft, then formed his own Progressive, or Bull Moose, party to contest the election, thereby scattering the Republican vote and bringing victory to Democrat Woodrow Wilson). Surely, therefore, it must record one of Roosevelt's innumerable squabbles during a tough political year. It does not. Francis H. Allen published these words in an ornithological journal, *The Auk*. He was writing about flamingos.

When, as a cynical and posturing teenager, I visited Mount Rushmore, I gazed with some approval at the giant busts of Washington, Jefferson, and Lincoln, and then asked as so many others have—what in hell is Teddy Roosevelt doing up there? Never again shall I question his inclusion, for I have just discovered something sufficiently remarkable to warrant a sixty-foot stone likeness all by itself. In 1911, an ex-president of the United States, after seven exhausting years in office, and in the throes of preparing his political comeback, found time to write and publish a technical scientific article, more than one hundred pages long: "Revealing and Concealing Coloration in Birds and Mammals." (As a parochial note of some interest, Roosevelt published his work in the *Bulletin of the American Museum of Natural History,* our professional journal still vigorously in print.)

Roosevelt wrote his article to demolish a theory proposed by the artist-naturalist Abbott H. Thayer (and defended by Mr. Allen, who castigated Roosevelt for bringing the rough language of politics into a scientific debate). In 1896 Thayer, as I shall document in a moment, correctly elucidated the important principle of countershading (a common adaptation that confers near invisibility upon predators or prey). But he then followed a common path to perdition by slowly extending his valid theory to a doctrine of exclusivity. By 1909, Thayer was claiming that *all* animal colors, from the peacock's tail to the baboon's rump, worked primarily for concealment. As a backbreaking straw that sealed his fate and inspired Roosevelt's wrath, Thayer actually argued that natural selection made flamingos red, all the better to mimic the sunset. In the book that will stand forever as a monument to folly, to cockeyed genius, and to inspiration gone askew, Thayer stated in 1909 (in *Concealing-Coloration in the Animal Kingdom,* written largely by his son Gerald H. Thayer and published by MacMillan):

> These traditionally "showy" birds are, at their most critical moments, perfectly "obliterated" by their coloration. Conspicuous in most cases, when looked at from above, as man is apt to see them, they are wonderfully fitted for "vanishment" against the flushed, rich-colored skies of early morning and evening.

Roosevelt responded with characteristic vigor in his 1911 article:

> Among all the wild absurdities to which Mr. Thayer has committed himself, prob
> bly the wildest is his theory that flaming
> are concealingly colored because their fo
> mistake them for sunsets. He has nev
> studied flamingos in their haunts, he kno
> nothing personally of their habits or the
> enemies or their ways of avoiding their en
> mies . . . and certainly has never read an
> thing to justify his suppositions; these su
> positions represent nothing but pu
> guesswork, and even to call them guesswo
> is a little over-conservative, for they con
> nearer to the obscure mental process
> which are responsible for dreams.

Roosevelt's critique (and many othe
equally trenchant) sealed poor Thaye
fate. In 1896, Thayer had begun his ca
paign with praise, promise, and panac
(his outdoor demonstrations of disappea
ing decoys became legendary). He fac
the dawn of World War I in despair a
dejection (though the war itself grant
him limited vindication by using his val
ideas in theories of camouflage). He
mented to a friend that his avocation (c
fending his theory of concealing colo
ation) had sapped his career:

> Never . . . have I felt less a painter . . . I a
> like a man to whom is born, willy nilly,
> child whose growth demanded his energi
> he the while always dreaming that th
> growing offspring would soon go forth
> seek his fortune and leave him to his prof
> sion, but the offspring again and again
> ther unfolding some new faculties th
> must be nurtured and watched, or comi
> home and bursting into his parent's stud
> bleeding and bruised by an insulted wor
> continued to need attention so that the
> was nothing for it but to lay down the bru
> and take him once more into one's lap.

I must end this preface to my essay wi
a confession. I have known about Thaye
"crazy" flamingo theory all my prof
sional life—and for a particular reason.
is the standard example, always used

The day he left the village of his childhood for America.

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professors in introductory courses to illustrate illogic and unreason, and dismissed in a sentence with the ultimate weapon of intellectual nastiness—ridicule that forecloses understanding. When I planned my flamingo trilogy (this is the last, I promise), I decided to end—how else?—with red wings in the sunset. I thought that I would write a column about absurdity, another comment on unthinking adaptationism. But my research unleashed a cascade of discovery, leading me to Roosevelt and, more importantly, to the real Abbott Thayer, shorn of his symbolic burden. The flamingo theory is, of course, absurd—that will not change. But how and why did Thayer get there from an excellent start that the standard dismissive anecdote, Thayer's unfortunate historical legacy, never acknowledges? The full story, if we try to understand Abbott Thayer aright, contains lessons that will more than compensate for laughter lost.

Who was Abbott Handerson Thayer anyway? I had always assumed, from the name alone, that he was an eccentric Yankee who used wealth and social position to gain a hearing for his absurd ideas. I could find nothing about him in the several scientific books that cite the flamingo story. I was about to give up when I located his name in the *Encyclopædia Britannica*. I found, to my astonishment, that Abbott Thayer was one of the most famous painters of late nineteenth-century America (and an old Yankee to be sure, but not of the wealthy line of Thayers—see the biography by Nelson G. White, *Abbott H. Thayer: Painter and Naturalist*. Connecticut Printers, 1951). He specialized in ethereal women, crowned with suggestions of halos and accompanied by quintessentially innocent children. Art and science are both beset by fleeting tastes that wear poorly—far be it for me to judge. I had begun to uncover a human drama under the old pedagogical caricature.

But let us begin, as they say, at the beginning. Standard accounts of the adaptive value of animal colors use three categories to classify nature's useful patterns (no one has substantially improved upon the fine classic by Hugh B. Cott, *Adaptive Coloration in Animals*. London, Methuen, 1940). According to Cott, adaptive colors and patterns may serve as (1) concealment (to shield an animal from predators or to hide the predator in nature's never-ending game); (2) advertisement, to scare potential predators (as in the prominent false eyespots of so many insects), to maintain territory or social position, or to announce sexual receptivity (as in baboon rump patches); and (3) disguise, as animals mimic unpalatable creatures to gain

White (top) and red (bottom) flamingos against the skies at sunrise and sunset.

protection, or resemble an inanimate (and inedible) object (numerous leaf and stick insects, or a bittern, motionless and gazing skyward, lost amidst the reeds). Since disguise lies closer to advertisement than to concealment (a disguised animal does not try to look inconspicuous, but merely like something else), we can immediately appreciate Abbott Thayer's difficulty. He wanted to reduce all three categories to the single purpose of concealment—but fully two-thirds of all color patterns, in conventional accounts, serve the opposite function of increased visibility.

Abbott Thayer, a native of Boston, began his artistic career in the maelstrom of New York City but eventually retreated to a hermitlike existence in rural New Hampshire, where his old interests in natural history revived and deepened. As a committed Darwinian, he believed that all form and pattern must serve some crucial purpose in the unremitting struggle for existence. He also felt that, as a painter, he could interpret the colors of animals in ways and terms unknown to scientists. In 1896, Thayer published his first, landmark article in *The Auk:* "The Law Which Underlies Protective Coloration" (vol. 13, pp. 124–29).

Of course, naturalists had recognized for centuries that many animals blend into their background and become virtually invisible—but scientists had not properly recognized how and why. They tended to think, naively (as I confess I did before r research for this column), that protecti emerged from simple matching betwe animal and background. But Thayer c rectly identified the primary method concealment as countershading—a devi that makes creatures look flat. Anim must indeed share the right color and p tern with their background, but th ghostly disappearance records a loss of mensionality, not just a matching of col

In countershading, an animal's col are precisely graded to counteract the fects of sunlight and shadow. Count shaded animals are darkest on top, whe most sunlight falls, and lightest on the b tom (Thayer identified the adaptive s nificance of light bellies—perhaps t most universal feature of animal col ation). The precise reversal between int sity of coloration and intensity of illumi tion neatly cancels out all shadow a produces a uniform color from top to b tom. As a result, the animal becomes fl perfectly two dimensional, and cannot seen by observers who have, all their liv perceived the substantiality of objects shadow and shading. Artists have stru gled for centuries to produce the illusi of depth and roundness on a flat canv nature has simply done the opposite—s shades in reverse in order to produce an lusion of flatness in a three-dimensio world.

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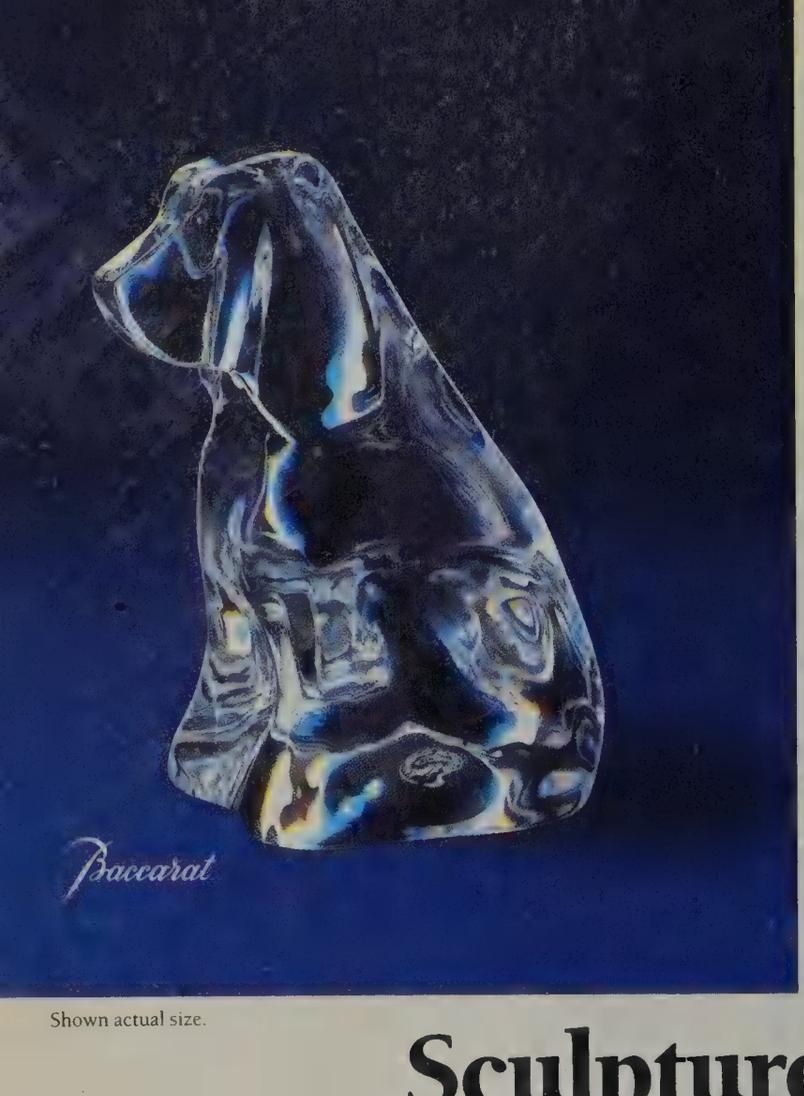

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countershading with older ideas about mimicry, Thayer wrote in his original statement of 1896: "Mimicry makes an animal appear to be some other thing, whereas the newly discovered law makes him cease to appear to exist at all."

Thayer, intoxicated with the joy of discovery, attributed his success to his chosen profession and advanced a strong argument about the dangers of specialization and the particular value of "outsiders" to any field of study. He wrote in 1903: "Nature has evolved actual art on the bodies of animals, and only an artist can read it." And later, in his 1909 book, but now with the defensiveness and pugnacity that marked his retreat:

> The entire matter has been in the hands of the wrong custodians . . . .It properly belongs to the realm of pictorial art, and can be interpreted only by painters. For it deals wholly in optical illusion, and this is the very gist of a painter's life. He is born with a sense of it; and, from his cradle to his grave, his eyes, wherever they turn, are unceasingly at work on it—and his pictures live by it. What wonder, then, if it was for him alone to discover that the very art he practices is at full—beyond the most delicate precision of human powers—on almost all animals.

So far, so good. Thayer's first articles and outdoor demonstrations won praise from scientists. He began with relatively modest claims, arguing that he had elucidated the basis for a major principle of concealment but not denying that other patterns of color displayed quite different selective value. Initially, he accepted the other two traditional categories—revealing coloration and mimicry—though he always argued that concealment would gain a far bigger scope than previously admitted. In his most technical paper, published in the *Transactions of the Entomological Society of London* (1903, pp. 553–56) and introduced favorably by the great English Darwinian E.B. Poulton, Thayer wrote:

> Every possible form of advantageous adaptation must somewhere exist . . . .There must be unpalatability accompanied by warning coloration . . . and equally plain that there must be mimicry.

Indeed, Thayer sought ways to combine ideas of concealment with other categories that he would later deny. He supported, for example, the ingenious speculation of C. Hart Merriam that white rump patches are normally revealing, but that their true value lies in a deer's ability to "erase" the color at moments of danger—a deer "closes down" the patch by lowering its tail over the white blotch and then disappears, invisible, into the forest. In his 1909 book, Thayer explicitly repudiated his former interpretation and argued for pure concealment—the white patch as "sky mimicking" when seen from below.

Thayer's pathway to perdition and ridicule followed a distressingly common route among intellectuals. Countershading for concealment, amidst a host of alternatives, was not enough. Thayer had to have it all. Little by little, plausibly at first, but grading slowly to red wings in the sunset, Thayer laid his battle plans (not an inappropriate metaphor for a father of camouflage). As article succeeded article, Thayer progressively invaded the categories of mimicry and revealing coloration to gain, or so he thought, more cases for concealment. Finally, nothing else remained: *all* patterns of color served to conceal. He wrote in his book: "All patterns and colors whatsoever of all animals that ever prey or are preyed upon are under certain normal circumstances obliterative."

Thayer made his first fateful step in his technical article of 1903. Here, he claimed a second major category of concealing coloration—what he called "ruptive" (we now call them "disruptive") bars, stripes, splotches, and other assorted markings. Disruptive markings make an animal "disappear" by a route different from countershading. They break an animal's coherent outline and make it appear as an insubstantial array of curious and unrelated patches (this principle, more than countershading, became important in military camouflage). A zebra, Thayer argues, does not mimic the reeds in which it hides; rather, the stripes break it up, and predators see no coherent prey at all.

Again, Thayer had proposed a good idea for some, even many, cases (though not for zebras, who rarely venture into fields of reeds). His 1903 article argues primarily that butterflies carry disruptive pictures of flowers and background scenery upon their wings: "The general aspect of each animal's environment," Thayer wrote, "is found painted upon his coat, in such a way as to minimize his visibility, by making the beholder think he sees *through* him."

But, amidst his good suggestions, Thayer had made his first overextended argument. Countershading could scarcely be mistaken for anything else and offered little scope for claiming too much. But the principle of "ruptive" concealment permitted enormous scope for encompassing other patterns that actually serve to reveal or mimic. Color patches and splotches—the classic domain of warning and revealing patterns (consider the peacock's tail)—could, for an overenthusiast like Thayer, become marks of disruptive concealment. Thus, to cite just one example of overstatement, Thayer argued in a 1909 article, adversarily entitled "An Arraignment of the Theories of Mimicry and Warning Colors" (*Popular Science*, December), that white patches on a skunk's head mimic the sky when seen by mice from below:

> Such . . . victims as can see would certainly have much more chance to escape were not what would be a dark-looming predator's head converted, by its white sky-counterfeiting, into a deceptive imitation or mere sky.

Still, by 1903, Thayer was not yet ready to claim concealment for all colors. He admitted one category of obvious conspicuousness: "Only unshiny, bright monochrome is intrinsically a revealing coloration."

Now we can finally understand why Thayer was eventually driven to his absurd argument about flamingos and the sunset. Divorced from the context of Thayer's own personal development, the idea sounds like simple disembodied craziness—as professors always present it for laughs in introductory classes. (Indeed, so far as I know, no one, before this essay, has ever tried to make sense of Thayer's ideas by tracing them chronologically through his papers.) Once Thayer decided to go for broke, and to claim that all color works for concealment, flamingos became his crucial test, his do or die attempt at exclusivity. As a last shackle before the final plunge, Thayer had admitted that stark monochromes—animals painted throughout with one showy color—were "intrinsically revealing." If he could show that such monochromes also served for concealment, then his triumph would be complete. Flamingos occupied the center of his daring, not a curious diversion. He had to find a way to fade bright red into ethereal nothingness. Hence the sunset—his as well as the flamingo's.

So Thayer visited the West Indies, got down on his belly in the sulfurous muds, and looked at flamingos—not comfortably down from above (as he always accused lazy and uncritical zoologists of doing), but from the side as a slithering anaconda or a hungry alligator might. And he saw red wings fading into the sunset—the entire feeding flock became a pink cloud, a "sky-matching costume":

> These birds are largely nocturnal, so that the only sky bright enough to show any color upon them is the more or less rosy and golden one that surrounds them from sunset till dark and from dawn until soon after sun-

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rise. They commonly feed in immense, open lagoons, wading in vast phalanxes, while the entire real sky above them and its reflected duplicate below them constitute either one vast hollow sphere of gold, rose, and salmon, or at least glow, on one side or the other, with these tones. Their whole plumage is a most exquisite duplicate of these scenes . . . .This flamingo, having at his feeding time so nearly only sunrise colors to match, wears, as he does, a wonderful imitation of them.

Thayer had finally gone too far and exasperated even his erstwhile supporters. His exaggerations—particularly his flamingos—now brought down a storm of criticism, including Roosevelt's hundred-page barrage. Critics pointed out that Thayer was wrong in every particular: Flamingos do not concentrate their feeding at dawn and dusk, but are active all day; anacondas and alligators do not inhabit the thin films of saline ponds that flamingos favor; flamingos eat by filtering tiny eyeless animals that cannot enjoy the visual pleasures of sunset.

Most sadly, Thayer's argument even failed in its own terms—and Thayer, who was overenthusiastic to a fault, but neither dishonest nor dishonorable, had to confess. Any object viewed *against* the fading light will appear dark, whatever its actual color. Thayer admitted this explicitly by painting a dark palm tree against the sunset in his infamous and fanciful painting of fading flamingos (reproduced here). Thus, he could only claim that flamingos looked like the sunset in the *opposite* side of the sky: red clouds of sunset in the west, red masses of flamingos in the east. Would any animal be so confused by two "sunsets," with flamingos showing dark against the real McCoy? Thayer admitted in his 1909 book:

Of course a flamingo seen against dawn or evening sky would look dark, like the palm in the lower left-hand figure, no matter what his colors were. The . . . right-hand figures, then, represent the lighted sides of flamingos at morning or evening, and show how closely these tend to reproduce the sky of this time of day; although always, of course, *in the opposite quarter of the heavens* [Thayer was good enough to underline his admission] from the sunset or dawn itself.

As a final, and feeble, parting salvo, Thayer added: "but the rosy hues very commonly suffuse both sides of the sky, so that . . . the flamingos illuminated ruddy color very often has a true 'background' of illuminated ruddy sky."

Teddy Roosevelt was particularly perturbed. As an old big-game hunter, he knew that most of Thayer's "ruptive" patterns did not conceal quarries. How could Thayer have it both ways—how could a lion be concealed in the desert, the zebra amongst the reeds when, in fact, they share the same habitat, often to the zebra's fatal disadvantage? Thus, Roosevelt decided to counterattack and wrote his scientific *magnum opus* during some spare time amidst other chores. He saved his best invective for the poor flamingos. Writing on February 2, 1911, to University of California biologist Charles Kofoid, he stated:

[Thayer's] book shows such a fantastic quality of mind on his part that it is a matter of very real surprise to me that any scientific observer . . . no matter how much credit he may give to Mr. Thayer for certain discoveries and theories, should fail to enter the most emphatic protest against the utter looseness and wildness of his theorizing. Think of being seriously required to consider the theory that flamingos are colored red so that fishes (or oysters for that matter—there is no absurdity of which Mr. Thayer could not be capable) would mistake them for the sunset!

The debate between Roosevelt and Thayer developed into an interesting discussion of scientific methodology, not merely some rhetorical sniping about specifics. To grasp Roosevelt's primarily methodological (and cogent) objections to Thayer's work, consider Thayer's most remarkable painting of all—the frontispiece to his 1909 book, showing a peacock obliterated in the foliage. Here, Thayer argues that every nuance of a peacock's coloration increases his concealment in a particular bit of habitat—the combined effect adding to invisibility. Given the usual interpretation of a peacock's color as revealing, and the gaudy impression that he makes both upon us and, one must assume, the peahen, Thayer's interpretation represents quite a departure from tradition and common sense:

The peacock's splendor is the effect of a marvelous combination of "obliterative" designs, in forest-colors and patterns. . . . All imaginable forest-tones are to be found in this bird's costume; and they

Peacock in the Woods, *painted by Abbott Thayer 1909.*

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"melt" him into the scene to a degree past all human analysis.

Thayer then positions his bird so precisely that all features blend with surroundings. He paints the blue neck against a gap in the foliage, so that it may mimic "blue sky seen through the leaves." He matches the golden greens and browns of the back to forest tones. He depicts the white cheek patch as a "ruptive" hole that disaggregates the face. He paints the celebrated ocelli (eyespots) of the tail feathers as leaf mimics. He also notes that ocelli are smallest and dimmest near the body, grading to larger and brighter toward the rear end: "They inevitably lead the eye away from the bird, till it finds itself straying amid the foliage beyond the tail's evanescent border." The spread tail, he claims, may impress the peahen, but it "looks also very much like a shrub bearing some kind of fruit or flower." Finally, he argues that the tail's coppery brown color represents perfectly "the bare ground and tree-trunks seen between the leaves."

What a tour de force, but what can we possibly make of it? Who would doubt that some conceivable habitat might conceal almost any animal? Note how precisely the peacock must choose his spot to receive the cryptic benefit that Thayer wishes to confer upon him. In particular, he must always place his shimmering blue neck in a gap amidst the foliage where it will vanish against a clear sky (but what does he do on a cloudy day, or in a bush so dense that no holes exist, as seen from all relevant directions at once?). Peacocks, in any case, live primarily in open fields. Their spreading display is a glory to behold—and the very opposite of invisible.

Thayer, of course, knew all this. He didn't claim (as his critics sometimes charged) that a habitat offering protection by concealment must be the usual, or even a common, haunt of its invisible beneficiary. Thayer simply argued that such protection might be important at critical moments occurring only once or twice in an animal's lifetime—at crucial instants of impending death from a stalking predator.

But how could odd and improbable moments shape such complex and intricate patterns as the innumerable details of a peacock's design? We finally arrive at the key theoretical issue of this debate—the power of natural selection itself. In order to believe that complex designs might be constructed by such rare and momentary benefits as sunsets or particular positions in trees outside an animal's normal habitat, one must have an overarching faith in the power of natural selection. Selection must be so potent that even the rarest c benefits will eventually be engraved int the optimal designs of organisms. Thaye has this faith; Roosevelt, and most biolo gists then and since, did not. Thayer wrot in 1900 (*The Auk,* vol. 17): "Of course, t any one who feels the inevitability of natu ral selection, it is obvious that each orga or structural detail, and likewise eac quality of organic forms, owes its exis tence to the sum of all its uses." Thaye then laid it on the line in stark epitome— patterns of color are built by natural selec tion "pure, simple and omnipotent."

Roosevelt and other acute critics co rectly identified the central flaw i Thayer's science—not in his numerou factual errors, but in his methodolog Thayer found a hiding place for all his an mals but with a method that made his the ory untestable and therefore useless t science. Thayer insisted that he ha proved his point simply by finding *an* spot that rendered an animal invisible. H didn't need to show that the creature usu ally frequented such a place or that the lo cation formed part of its natural habitat a all. For the animal might seek its spot onl in the rarest moments of need. But ho then could we disprove any of Thayer claims? We might work for years to sho that an animal never entered its domain c

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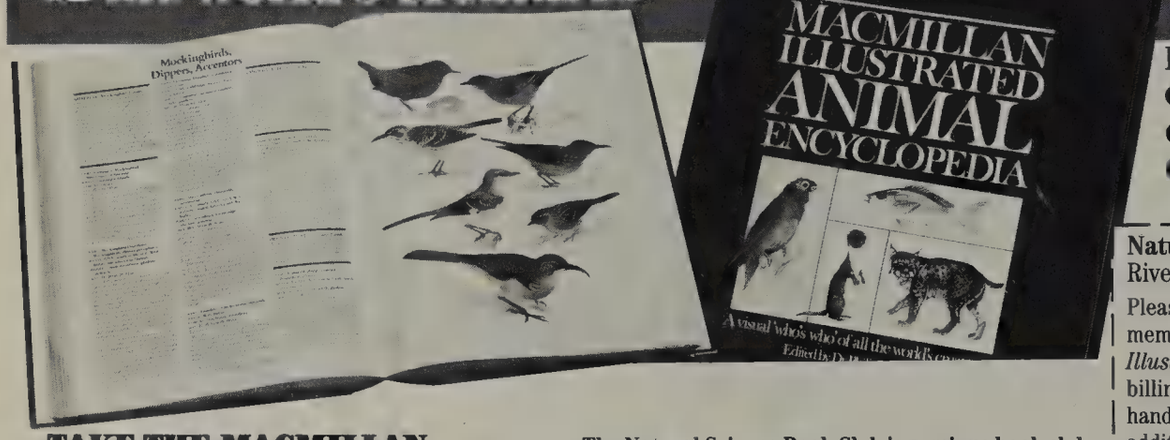

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nvisibility, and Thayer would reply: Wait ill tomorrow when urgent need arises. Scientists are trained to avoid such special pleading because it exerts a chilling and stupefying effect upon hypotheses, by rendering them invulnerable to test and potential disproof. Doing is the soul of science and we reject hypotheses that condemn us to impotence.

T. Barbour, former director of Harard's Museum of Comparative Zoology where I now sit composing this piece), and J.C. Phillips emphasized this point in reviewing Thayer's book (*The Auk,* vol. 28, 1911):

Acquiescence in Mr. Thayer's views throws a pall over the entire subject of animal coloration. Investigation is discouraged; and we find jumbled together a great mass of fascinating and extremely complicated data, all simply explained by one dogmatic assertion. For we are asked to believe that an animal is protectively clothed whether he is like his surroundings, or whether he is very unlike them (obliteratively marked) or . . . if he falls between these two classes, there is still plenty of space to receive him.

Teddy Roosevelt addressed the same issue with more vigor in a letter to Thayer on March 19, 1912 (just imagine any presidential candidate taking time out to pursue natural history more than a month after the New Hampshire primary—oh, I know, campaigns were shorter then):

There is in Africa a blue rump baboon. It is also true that the Mediterranean Sea bounds one side of Africa. If you should make a series of experiments tending to show that if the blue rump baboon stood on its head by the Mediterranean you would mix up his rump and the Mediterranean, you might be illustrating something in optics, but you would not be illustrating anything that had any bearing whatsoever on the part played by the coloration of the animal in actual life . . . .My dear Mr. Thayer, if you would face facts, you might really help in elucidating some of the problems before me, but you can do nothing but mischief, and not very much of that, when conducting such experiments . . . .Your experiments are of no more real value than the experiment of putting a raven in a coal scuttle, and then claiming that he is concealed.

Contemporary (and later) accounts of Thayer's debacle rest largely upon a red herring, concealed in more than the sunset, that will not explain his failure and that only reinforces a common and harmful stereotype about the intrinsic differences between intellectual styles. In short, we are told that Abbott Thayer ultimately failed because he possessed an artist's temperament—good for an initial insight perhaps, but with no staying power for the hard (and often dull) work of real science.

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Such charges were often lodged against Thayer, and with undoubted rhetorical effect, but they represent a dangerous use of ad hominem argument with anti-intellectual overtones. Thayer may have laid himself open to such ridicule with a passionate temperament that he made no effort to control in a more formal age. John Jay Chapman, the acerbic essayist, wrote of Thayer (admittedly in a fit of pique when his wife, at his great displeasure, decided to study art in Thayer's studio):

> Thayer by the way, is a hipped egoist who paints three hours, has a headache, walks four hours—holds his own pulse, wants to save his sacred light for the world, cares for nobody, and has fits of dejection during which forty women hold his hand and tell him not to despair—for humanity's sake.

But is such passion the exclusive birthright of artists? I have known many scientists equally insufferable.

Thayer's scientific critics also raised the charge of artistic temperament. Roosevelt wrote, in a statement that might have attracted more attention in our litigious age: Thayer's misstatements "are due to the enthusiasm of a certain type of artistic temperament, an enthusiasm also known to certain types of scientific and business temperaments, and which when it manifests itself in business is sure to bring the owner into trouble as if he were guilty of deliberate misconduct." Barbour and Phillips argued that "Mr. Thayer, in his enthusiasm, has ignored or glossed over with an artistic haze . . . .This method of persuasion, while it does appeal to the public, is—there is no other word—simple charlatanry however unwitting." Barbour and Phillips then defended the cold light of dispassionate science in a bit of self-serving puffery:

> [Our statements] are simply the impressions made upon open-minded observers who have no axe to grind, and who have no reason to take sides on the question, one way or another. They have been written in a friendly spirit, and we hope they will be received in the same way.

Do friendly spirits ever accuse their opponents of "simple charlatanry"?

The charge of artistic temperament may be convenient and effective, especially since it appeals to a common stereotype—but it won't wash. The facile interpretation that scientists wouldn't give Thayer a hearing because he was an "outsider" won't work either—for contemporary accounts belie such charges of territoriality and narrowness. Even though Thayer made such strong claims—quoted above—for scientists' incompetence in a domain accessible only to artists, naturalists welcomed his insights about countershading and enjoyed both his initial articles and his outdoor demonstrations. E.B. Poulton, one of England's greatest evolutionists, warmly supported Thayer and wrote introductions to his publications. Frank M. Chapman, great ornithologist and editor of *The Auk,* wrote in his *Autobiography of a Bird Lover:*

> As an editor, doubtless my most notable contributions to the Auk's pages were Abbott Thayer's classical papers on protective coloration . . . .I knew little of Thayer's eminence as an artist. It was the man himself who impressed me by the overwhelming force of his personality. He made direct and inescapable demands on one's attention. He was intensely vital and lived normally at heights which I reached only occasionally and then only for short periods.

Thayer's ultimate failure reflects a more universal tendency, distributed without reference to profession among all kinds of people. Nothing but habit and tradition separate the "two cultures" of humanities and science. The processes of thought and modes of reason are similar—so are the people. Only subject matter differs. Science may usually treat the world's empirical information; art may thrive on aesthetic judgment. But scientists also traffic in ideas and opinions, and artists surely respect fact.

The *idée fixe* is a common intellectual fault of all professions, not a characteristic failure of artists. I have often written about scientists as single-mindedly committed to absurd unities and false simplifications as Thayer was devoted to concealing coloration as an exclusive principle in nature. Some are charming and a bit dotty—as old Randolph Kirkpatrick, who thought that all rocks were made of single-celled nummulospheres (see my column of March 1978). Others are devious and more than a bit dangerous—as Cyril Burt who fabricated data to prove that all intelligence resided in heredity (see my book *The Mismeasure of Man*).

Abbott Thayer had an *idée fixe;* he burned with desire to reduce a messy and complex world to one beautiful, simple principle of explanation. It doesn't work. History has built irreducible complexity and variety into the bounteous world of organisms. Diversity reigns at the superficial level of overt phenomena—animal colors do many different things. The unifying principles are deeper and more abstract—may I suggest evolution itself for starters.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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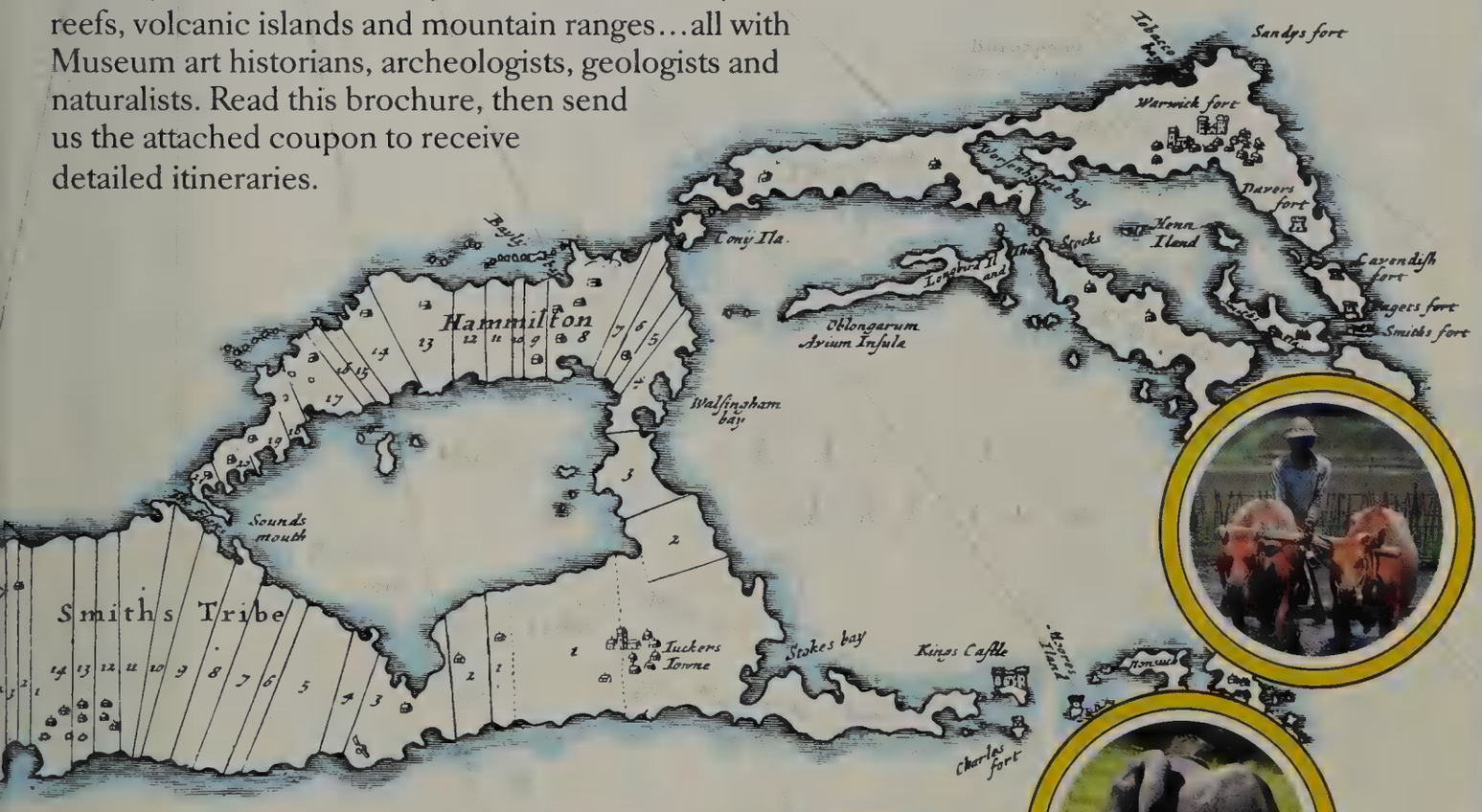

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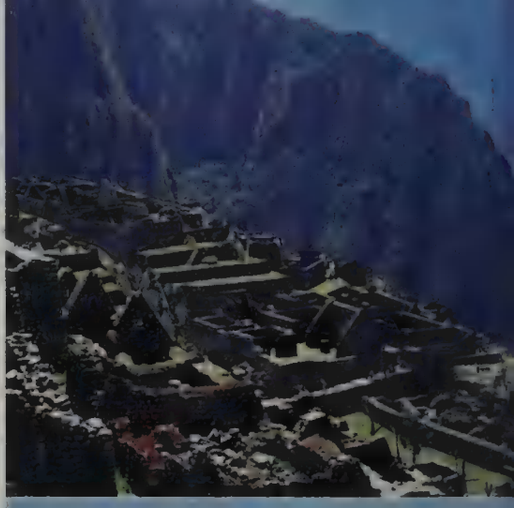

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Dinty Moore of Lake Becharof

And other brown bears I've met along the trail

by Derek Stonorov

I've never had a brown bear touch me or anyone I've been with. Other than the ones I've tranquilized, I've never touched a bear except once, when I hit a friendly one with a snowball. I've met bears in the alders, bears on the beach, bears in the middle of streams, bears that were eating, bears that were sleeping, even bears that looked amorous. I've chased bears off moose kills and bears off dead seals; I've inadvertently separated sows from cubs. I've met bears of forty pounds and bears of half a ton. I've met bears on snow slides in the spring and bears in berry patches in the fall. I've interrupted their peace many times . . . but so far things have gone well. Karma? Perhaps. Luck? Lots of it. Respect? Certainly.

I have always kept track of my encounters with bears. The summers that I studied how bears communicated with each other at McNeil River in Alaska, I also kept an account of how they interacted with me. Immediately after a bear and I had separated, I'd write down the visual and vocal signals observed and the sequence they occurred in. I divided each encounter between the bears and myself into three parts. The first I called the identification phase, the second the aggressive display, and the third, for the purpose of gathering information on habituation, subsequent behavior.

The identification phase started when the bear began to do anything bears commonly do to identify strange objects in their environment. Facing toward me and sniffing were the most common indicators that the bear had sensed my presence and was curious. Sometimes it would stand up on its hind legs, in an apparent attempt to locate me visually. Bears in tall grass, as one would guess, are more apt to stand up than bears in open tundra. I have never found any indication that this standing up, no matter how dramatic, is a signal of aggression or of an intent to dominate. It is seldom used once identification has been made, except as a way of tracking an adversary at a distance. During this identification period, the ears would be forward and facing toward me, as if the bear was trying to figure out what I was by the sounds I made. The mouth could be seen opening and closing slightly. If I was feeling really cool, I would look through my binoculars and detect nostril movement. At this point sucking and blowing sounds would often be heard as the bear pulled in and expelled air, most likely trying to identify or locate my scent. In brown bear country, you can sometimes hear these sounds when you're in heavy cover—but never see the bear making them.

During the identification phase a bear would often circle me, apparently trying to find a spot where he could get my scent or a better view. This was far more common the first time I met a bear than afterward. Also, bears that were a hundred yards away did it more often than those that were closer.

At this point, if the bear moved toward me or away from me, that was the beginning of what I consider an aggressive display. Obviously, there is a good bit of overlap between what I call identification and what I call aggression because many actions signal more than one thing. Also, what I do is important. While I tried to keep my behavior simple and consistent—I either stood still or slowly backed away—even slight variations in how I acted often altered what happened. Usually, the display part was very short; the bear would move off doing nothing more than occasionally looking at me over its shoulder—mouth and nostrils moving, ears forward, and then back against the head. If, however, the bear decided to pursue me or at least come closer, I saw other aggressive signals: the classic stiff-legged look, a slowdown in movement, chomping with the mouth, loud growls, and perhaps a few short lunges.

If the bear now resumed what it had been doing before the confrontation with me, or if it stopped giving aggressive signals, I considered the final part, or the subsequent behavior phase, to have started. Even when the bear was the obvious victor, and forced me to move, about 85 percent of the time it moved to a new spot before resuming its activities. The distance a bear moved was not predictable. Two encounters between man and bear on the McNeil Tidal Flats demonstrate the extremes of behavior one can observe.

First Encounter

MAN: Walking on bear trail

BEAR: Eating sedge grass alongside trail

MAN: Sees bear, stops, stands motionless fifty feet away

BEAR: Senses man, stops eating, faces man for three seconds

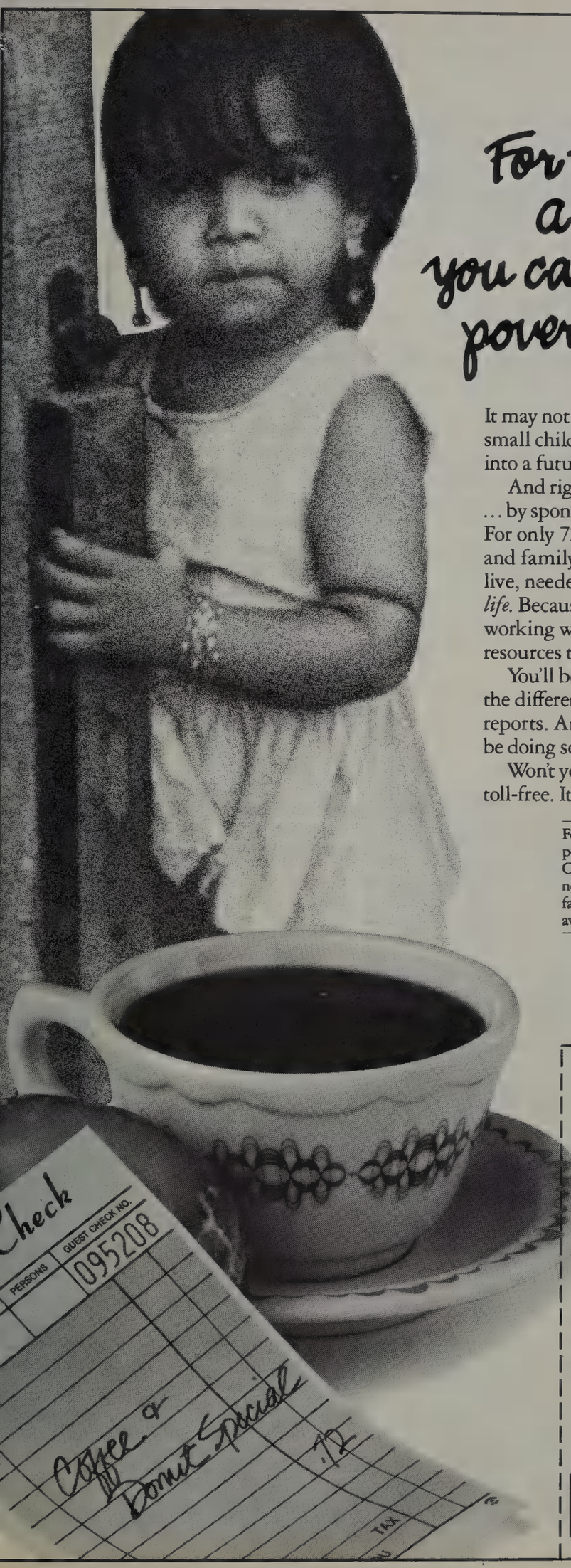
MAN: Remains motionless

BEAR: Turns head away, moves one hundred feet from man, sits down, resumes eating

MAN: Slowly moves away

Second Encounter

MAN: Walking on bear trail



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BEAR: Eating sedge grass alongside trail

MAN: Sees bear, stops, stands motionless one hundred feet from bear

BEAR: Senses man, stops eating, stands on hind legs to look

MAN: Looks at bear, remains motionless

BEAR: Staggers backwards, drops, and runs

MAN: Continues walking on bear trail

BEAR: Still running when glimpsed one mile off

The intensity of the interactions between man and bear lessens as the two become used to each other. Bears are intelligent animals, and after a few meetings with humans they are likely to calm down (as do the humans) and tolerate people at close range. This may be a positive change, but one must be constantly aware that if a bear suddenly perceives you as a danger, there may not be much time to react.

There are at least three reasons a bear might respond aggressively to a person—to defend its individual distance or personal space, to defend its young, or to defend its food source.

It is difficult to measure individual distance—the space around an animal that if violated will cause the animal to attack or flee. Sometimes the distance is twenty-five feet, sometimes hundreds of yards. I have found that the biggest variable is how the bear becomes aware of me and vice versa. That I can't control. If I wake a bear that has been napping in the alders and it goes crashing off while I am still fifty feet away, that's one thing. I can't really compare it to a situation in which a bear in a tidal meadow spots me from six hundred yards and lets me approach to within one hundred yards before slowly moving off. In encounters that are alike—man meets bear in tidal meadow or man meets bear on open hillside—there seems to be a correlation between how far apart the two parties are when they become aware of each other and the subsequent intensity of the bear's reaction (and likely the man's too!). Whether or not a bear has gotten used to humans also has an effect. The safest thing to say is that the area a bear will defend is directly dependent on the individual bear, the situation, and how the bear perceives the threat.

If you violate a bear's personal space, you may get a reaction; but if the bear is with young, it becomes much more likely. This is the most common cause of damage between man and bear. One reason that a sow is so fierce in her defense is that large male bears are sometimes cannibalistic. If given the chance, an old male may pick off a cub. Another reason is that on occasion bear cubs become the prey of other animals. Twice I have seen wolves approach sows with cubs; the wolves were driven off. I'd venture to guess that a first-year cub wouldn't be much of an adversary for a full-grown wolf that might outweigh it two to one. Both times I saw them, the wolves were fishing and not stalking, but the sow still saw fit to charge and chase.

A threat to its food could provoke a bear, too. In my experience, bears have left their food rather than tangle with me, but I know this is not always the case. Again one must be aware of the variables. How satiated is the bear? What is its social status? Some bears feeding on dead animals are likely to charge anything that moves; on the other hand, a timid subadult may run from a passing raven.

Defense of personal space, young, or food are all reasons a bear might become aggressive, but these don't cover every circumstance. In some of my encounters with bears, the bear's motivation has been difficult to explain.

Give a kitten a ball, place a new object in the cage of a laboratory rat, and it is easy to see exploratory behavior. I believe that some man–bear interactions begin when the bear simply becomes curious about the man and decides to explore. Many biologists, myself among them, believe that it is to the biological and evolutionary advantage of an animal to explore its environment. This behavior has survival value; some aspects of it can be seen in the predatory behavior of carnivores. However, what starts out as exploratory behavior need not end in a charge.

Many times an encounter between me and a bear started when the bear, noticing I was observing it, began investigating me in turn. This type of behavior seldom developed into a display of much intensity; most of the incidents could hardly be termed aggressive. Commonly the bear would approach where I was sitting, sniff, face me, turn, and depart. While the bear sniffed and looked me over, I often got the feeling from the way it moved that it was making up its mind whether to move closer or flee. Sometimes a bear would seemingly test my mettle—or its own—and growl and stalk around in a disgruntled way before departing. Only once did a large bear approach me like this, and never has a sow with cubs done it. Usually the bears that spot me and come over are juveniles; possibly they haven't learned their manners yet. One, which I named Dinty Moore of Lake Becharof, saw fit to approach and threaten me four times in ten hours. Holy Joe and Henderson—two young bears I believe were litter mates—also of Lake Becharof—frequently hung around me, although once they tried a bluffing charge from sixty feet out. The motivation of a bear in this type of situation is difficult to assess, but in twenty-five cases that I have documented, in which I was in the open and the bear came at me, I am confident I was seeing exploratory behavior.

A predator–prey relationship is another possible reason for man–bear encounters. Tragically, some people have been killed and eaten by bears. While this almost never happens, the fact that it has shows one more aspect of the complicated organism that is the brown bear.

Whether a bear would ever intentionally prey on humans is a subject of debate, but there is little doubt that if you run quickly from a displaying bear you may trigger a chasing response that could lead

Larry Aumiller; Bruce Coleman Inc.

Alaskan brown bears near McNeil River

a truly predatory act—that is, killing nd even eating. I have no data on this nasing instinct, a bit of behavior that is eported for most predatory species, but I elieve in it enough to have never run flat ut from a displaying bear. And on three ifferent occasions that I know of when a rge bear killed a smaller bear, the victim ad run away from a confrontation and as dragged down.

One other, lesser-known reason bears ometimes confront people is social status. human in a bear's environment is likely be tested and treated like a bear. This is he reason that if you see a large male bear alking down a trail and you are going gainst traffic you should give him room. is normal manner with other bears is to eep moving, head down, ears back, eyes the stranger, frontal body orientation, nd perhaps a growl. This is common be-avior. Large males are used to dominat-g a situation and are quite willing to in-rease the intensity of their display in rder to proceed. If coming toward you hile making the above-mentioned signals enough to move you, the bear will pass by. If it takes a knock down, drag-out ght to move you, the bear will do that, hen pass on by. I once saw Killer, the top-nking and largest male at McNeil, re-ove a large male called Patches from a ear trail by picking up the 750-pound ear in his mouth—removing a six-by-ght-inch piece of hide in the process—ushing him down a bank, and then pro-eeding to a fishing spot as if nothing had appened. What appeared to me a hercu-an task, and a very stressful situation, dn't even delay Killer's lunch.

While it is unpleasant to have a bear ominate you, it is better to be dominated nd treated like a lesser bear than to be aten or mauled. Usually, human victims bears are hurt but not killed, and the ears leave after a few seconds of contact. his leads me to believe that most of the me the bear is treating the human as it ould another bear, using ritualized bear ehavior. Unfortunately, humans can be riously injured by what, for a bear, mounts to a cuff or a nip. On nine occa-ons I have seen sow bears bite fleeing ubadults on the bottom after the sub-dults came too close to them. These were ot playful nips—they would have done in nything weaker than a brown bear, and ey were all preceded by full-blown, gh-powered, forty-mile-an-hour, earth-aking charges, and all manner of ntagonistic signals.

All of this raises the question of how umans should behave around brown ears. When I unexpectedly meet a bear, e first things that go through my mind

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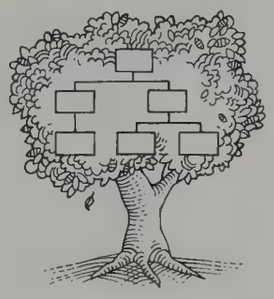

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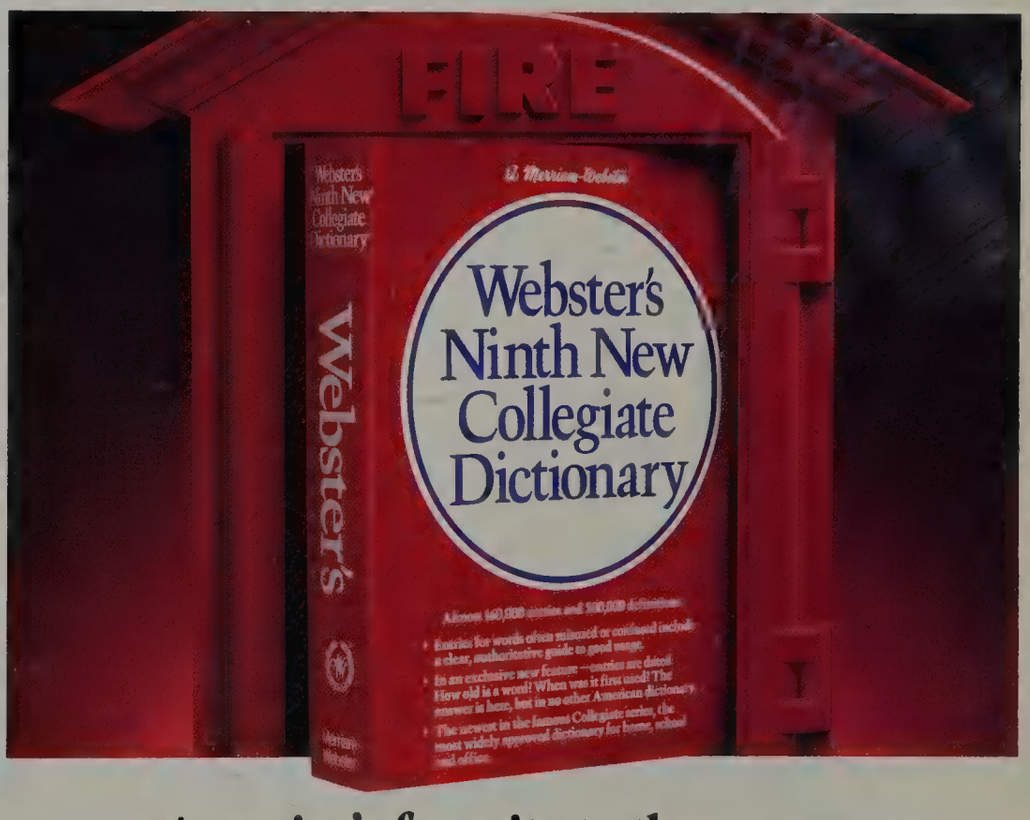

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are: Does the bear have enough room to move, and does the bear think I have it trapped? A sow with cubs just might not be willing to take her family past four other bears to increase her distance from you. A small bear may have just lost a battle with a larger foe and may figure that it is easier to get by you than return and be beaten again.

Once, three friends of mine and I were walking home on the beach when we spotted a bear several hundred yards away coming toward us. There were sheer cliffs on one side and the incoming tide on the other, the proverbial rock and a hard place. I felt that because there were four of us and it was a very small bear, it would turn and run from us. We were in a hurry as high tide made several creeks impossible to ford, which, in turn, made the walk back to camp a mile or so longer. The beach was perhaps 30 feet wide. We very foolishly kept on going, yelling at the bear. He kept on coming. We kept on yelling. At 150 feet he began to display, growling and working his mouth. We stopped our progress and all backed up as a unit. He came on but did not shorten the distance between us. Finally, after perhaps three minutes and 100 yards, we came to a break in the cliff and he got opposite us; he broke into a run and maintained that run for a good 300 yards. What was on that bear's mind, I do not know. I do know that we were wrong to initiate the confrontation. You can't force your time schedule on a bear. If you are willing to sacrifice slightly—a ten-minute wait or a mile extra walk—your chances of being hurt will be vastly reduced.

The most important thing to remember in brown bear country is that the only wild animal out there is you. You stick out like a sore thumb to the local inhabitants, and besides that, you apparently stink and wear a raincoat. You are the only animal around that lacks interspecific tact and the speed to escape interspecific strife.

And another thing: Give the bears a break, leave your watch at home. One of the most common reasons I have heard for forcing a bear to move is, "Well, I was in a hurry." In a hurry to do what? Die? Kill the bear? Relax and go slowly. Find a good berry patch to graze in for a while if a detour around a bear is impossible. Forget the Judeo-Christian ethic that places men above all. Treat the bear at least as an equal, not as a rug. Before you depart on a wilderness trip, get a little philosophical about bears and what they mean to you and the world.

I also keep out of the alders and places that are hard to see into. Bears like to bed up in cover and have been known to take unkindly to being awakened. It is common for bears in cover to completely panic when they smell a human and to take off not realizing or knowing where you are. They will come by at a great rate. If you are in the way, you could be pushed, trampled, or else just scared to death. If you have to pass through cover, make some noise. You don't have to disrupt the cosmos, but it doesn't hurt to give the bear some warning.

Bear trails are bear highways. Some of them have been used extensively for hundreds of years. Bears are not random walkers. They don't just go anywhere. If you see a bear coming and you don't want to talk to him, move off the trail and chances are he will go right on by. If you are going to stay in one area, try to use the same trails as much as possible, even the same trails at the same times. Bears space themselves from each other by space and time. People should do the same. Once the bears learn your routes they will keep clear. Don't camp on bear trails. This is one of the oldest mistakes in the book. Look around before pitching your tent. Beaches, stream banks, and lake shores all usually have bear trails. Keep off them or if you insist, leave something in the trail so the first thing the bear discovers isn't you. It goes without saying that the height of foolishness and bad manners is to camp without a tent in a bear trail. Better to have the bear sniff the tent prior to sniffing your face.

Cleo Creek runs into Lake Becharof about a mile south of the cabin where we lived. There's a sand bar at the end of the creek. To get to Cleo Creek, you walk out the front of the cabin, turn left, and proceed along the lake shore, fording Cleo Creek at the sand bar. About one hundred feet past the mouth of Cleo Creek is an old cabin. We used to climb up on the roof there to watch the bears fish.

One afternoon I watched a bear that was new to me chase every regular Cleo Creek bear off the bottom half-mile of creek. The new bear, a medium-sized male, chased fish when not chasing other bears. He'd go roaring upstream, and the shallow water would boil as hundreds of salmon tried to escape. A few minutes later, he'd be back at a gallop, the salmon swimming downstream this time to get away. Sometimes a fish would beach itself in its escape attempt and the bear would grab it and disappear in the alders for a meal. It was beginning to get dark, and the bear had made one of its upstream runs when I decided to go home.

I was just crossing the creek at the sand bar when the bear came back downstream. At fifty feet he stopped, looked, and began a dance of displeasure. His legs got stiff, his ears went back, and he made chomping noises with his mouth. I began to back out into the lake. He made a short charge out into the shallows but stopped and then moved laterally toward me for a few steps, keeping his eyes on me all the time. I backed out into the lake until the water came over the top of my hip boots and the bear just growled and watched me. I began to work my way up the shore away from the creek mouth. Abruptly the bear broke off the encounter, turned, and trotted off up Cleo Creek and out of sight. I got back on the beach and started home, not even bothering to empty the water from my boots. A hundred yards up the beach, who should I notice paralleling my progress home, perhaps one hundred feet away, but the bear. He stayed with me for ten minutes or so, quietly walking and watching. Finally he just disappeared and I went on to the cabin.

For that ten-minute walk home, the bear and I were in touch. When he charged me, I was scared as hell, but by the time I got near home I was sort of digging it. The next morning at 6 A.M. the bear again met me at the mouth of Cleo Creek—this time I had my wife with me—and he again charged, but after we subordinately waded into the lake he turned and went splashing off upstream.

All of which reminds me of the time in the summer of 1967, right up near the top of Bear Creek. I had been walking and looking for bears all day and I was hungry, so I sat down to eat a peanut butter and jelly sandwich. I had only taken a bite or two when a bear stuck its head out of an alder patch and began to click its teeth and lick its lips. Well, my gun was miles away back at camp, my Swiss army knife didn't look like a bear sticker, and I never felt I could kill a bear with my bare hands; and since the bear didn't look like it was going to leave, I gave it half my sandwich. I tossed it and the bear caught it and swallowed, much the same way a frog takes in a fly—I don't think it chewed. It must have liked whatever fleeting taste it got because it walked over and tore the other half of the sandwich out of my hand, taking two fingers and my thumb along with it. I turned to run, but the bear knocked me down with one blow of its front paw. The last thing I remembered was its rotten breath as its jaws closed on my head. And then? . . . and then? . . . Well, the truth of the matter is the bear killed and ate me.

Derek Stonorov does research on bears at Lake Becharof and the McNeil River in Alaska. This article was adapted from a work in progress.

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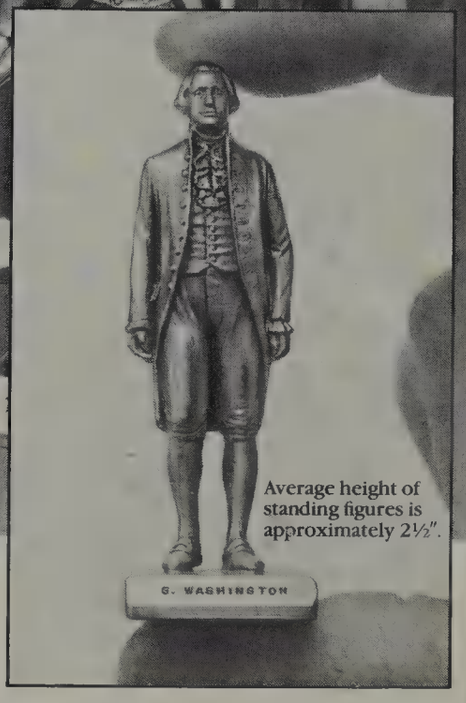

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Ancient Bristlecone Pine Forest, California

by Robert H. Mohlenbrock

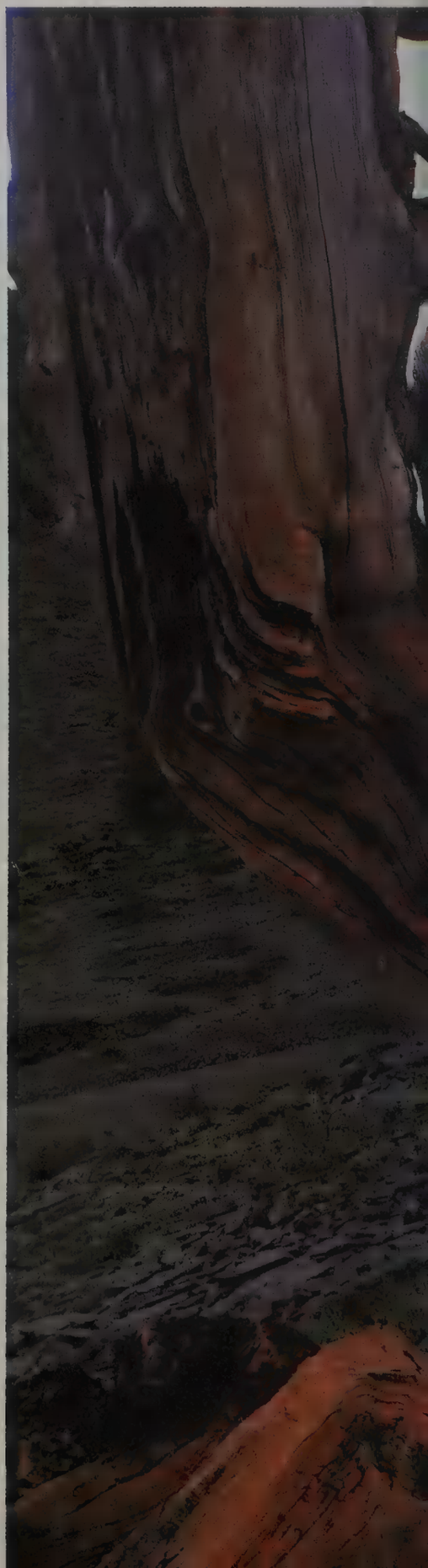
During each growing season, a tree adds a layer of wood to its trunk and branches, creating the annual rings we see in a cross section. The new wood cells arise from the living tissue that lines the bark. In the spring, when it is moist, the tree devotes most of its energy to growth; at this time, the new cells are relatively large, but as summer progresses, they get smaller and smaller. In the fall, the wood cells die, and no new cells are added until the following spring. The contrast between the last layer of small cells from one year and the first layer of large cells the next year is usually strong enough to make ring counting rather simple.

Early this century, A.E. Douglas of the University of Arizona observed that a wide ring, at least in some species of trees, indicated that the wood was formed during a wet year, whereas a narrow ring denoted a dry year. Archeologists, botanists, and foresters used this discovery to develop the science of dendrochronology—the dating of past events or climatic changes by the study of growth rings. Climate patterns in specific geographic areas can be ascertained by examining ancient living trees, and if suitable fragments of wood that overlap in age are found, the procedure can be extended back in time. Samples of unknown age can then be dated by matching their growth patterns with the established sequence of tree ring growth. For example, dendrochronologists have dated Pueblo Bonito, a prehistoric Indian settlement in New Mexico, back to the seventh century by analyzing the wood used in its construction.

In the 1950s, hoping to determine exactly when ancient droughts occurred in the Southwest, wood anatomist Edmund Schulman of the University of Arizona began a systematic search for the region's oldest trees. He knew that the oldest California redwoods were about 2,200 years old and that some western junipers in Yosemite were nearly 2,500 years old. Some giant sequoias have been living for more than 3,000 years; the famous General Sherman tree, for example, may be as much as 3,500 years old. But Schulman wanted to find still older trees. In 1953, while exploring the White Mountains on the California–Nevada border with Frits Went of the California Institute of Technology, Schulman stumbled onto a promising grove of weathered, gnarled bristlecone pines, most of which were clinging to life by a mere ribbon of living bark.

For the next several years, Schulman studied the growth rings of these trees, which looked liked living driftwood. Using a boring tool, he removed thin cylinders of wood from the trunks and counted their rings (although this procedure leaves a small opening, the pine's capacity to exude resin quickly into the wound prevents subsequent decay). The rings were minuscule, and counting them was no easy matter. Some of the trunk tissues had eroded away, and those rings that were left usually were not in neat concentric circles. The band of living tissue in an old, eroded stem sometimes grew at right angles to its original rings. Schulman had to match the rings of one tree with those of others that had the missing section or that were undistorted. His efforts were amply rewarded, however, as the remarkable ages of some of these trees began to emerge. The first tree Schulman found that was more than 4,000 years old he called Pine Alpha; later, he identified a 4,600-year-old denizen and christened it Methuselah. (During the 1960s, forester Donald Currey discovered a bristlecone pine near Wheeler Peak in eastern Nevada's Humboldt National Forest that is more than 4,900 years old!)

Several years ago I went to the Ancient Bristlecone Pine Forest, part of California's Inyo National Forest, to see Schulman's trees for myself. A Forest Service parking area is provided for the well-kept hiking trail known as Methuselah Walk, which circles past many of the oldest trees, including Pine Alpha and Methuselah. (I found that a leisurely pace was advisable to avoid exhaustion at the 10,000-foot elevation.) At the time I thought that any organism that lived longer than the norm had to have optimal conditions going for it. For plants, these conditions would be adequate moisture, moderate temperature, continuous sources of nutrients, and protection from severe weather. When I stood looking at Methuselah, I



A bristlecone pine in California's White Mountains
David Muench

knew I had been wrong. The cold was bone chilling (even in July), the patchy pockets of soil showed little evidence of moisture, and the wind battered my body with repeated gusts.

The bristlecones, along with the similar limber pines, dominate a subalpine coniferous forest that extends from about 9,500 feet up to timberline (about 11,800 feet), mostly within the western Rocky Mountains. The White Mountains, where Schulman found his trees, lie in the "rain shadow" of the towering Sierra Nevadas, which are to their west. Cyclones, moving inland from the Pacific Coast, shed their moisture before reaching the west slopes of the White Mountains, leaving only strong, dry winds that whip across the mountainsides. Rainfall is less than twelve inches per year.

The greatest concentration of very ancient trees is near the crest of a ridge, in exposed patches of dry, rocky, dolomitic limestone. The limestone is relatively cool because the light gray or even white ground surface reflects more solar radiation than nearby outcroppings of sandstone or granite. In addition, nutrients are readily leached from the porous dolomite. Yet under these harsh conditions, the trees here survive to extreme age. Mature pines that grow on sandstone or in protected areas are neither as misshapen nor as old.

Ancient Bristlecone Pine Forest

Joe LeMonnier

For visitor information, write:
Forest Supervisor
Inyo National Forest
873 North Main Street
Bishop, California 93514

The longevity of the pines appears to depend on their ability to develop and maintain a special growth habit. Trees 1,500 years old or older usually have only a narrow strip of living bark on the trunk and only a few living twigs and needles on one remaining live branch. The reduction of living tissue to a single strip results partly from weathering and abrasion by soil particles that remove the bark from the upper surface of the roots and partly from repeated loss of foliage and twigs on the windward side of the tree. These old trees grow exceptionally slowly, even during their very first year. Most of them produce only an inch or less of growth rings in a century. Schulman found one gnarled tree that was only three feet tall and had a trunk diameter of three inches; it was 700 years old.

Bristlecone pines that receive more moisture, more nutrients, and greater protection show comparatively fast growth during their early decades. These "normal" trees produce an increasing volume of new wood each year to maintain a constant annual increase in thickness around their symmetrical trunks. Like most trees, they become less efficient at absorbing and metabolizing carbon dioxide as they age. Consequently, they become uniformly sickly and die. But although most of an old bristlecone pine has already died over the centuries, a small living part of it remains healthy. Such a tree is able to maintain a constant ratio of living to nonliving tissue almost indefinitely with little expenditure of energy. During years with severe weather, minimal metabolic activity is required to keep the tree alive.

The durability of the exposed, dead wood contributes to the tree's longevity. In most trees, dead tissue ultimately rots and the tree falls, but in the old bristlecones, the nonliving wood remains sound throughout the life of the tree. This resistance may be due to the (as yet unexplained) greater than usual concentration of resin canals in the trunk and to the absence of wood-destroying fungi, which apparently cannot tolerate the cool, dry environment where old bristlecones grow. Fast-growing bristlecone pines in less rigorous habitats tend to develop heart rot after reaching a diameter of fifteen inches or so.

Other favorable conditions may also help explain the bristlecones' longevity. In the oldest groves, the trees are widely spaced, reducing or eliminating competition of tree roots and crowns. And the dolomite retains more moisture than either sandstone or granite. Consequently, the timberline on dolomite doesn't begin until about 11,800 feet, whereas the growth of trees on sandstone and granite ceases at 11,000 feet. Finally, at high elevations the dolomite that underlies the bristlecones supports very little understory vegetation, thus reducing the possibility of ground fire.

Jeff Gnass

An ancient bristlecone may contain no more than a thin ribbon of living bark.

A few miles north of Methuselah Walk is another impressive group of bristlecone pines—Schulman Grove. The Patriarch, the largest bristlecone pine in the world, grows here. Thirty-eight feet wide and forty feet high, the Patriarch is a tree to behold, yet scientists say it is a mere youngster, only about 1,500 years old.

At this point in history, the ancient bristlecones are a phenomenon, but experts predict that most of the old pines will succumb in a few centuries. Trees like the General Sherman sequoia, which, unlike the bristlecones, live under evident optimal conditions, seem destined to become the longevity champions. At 3,500 years, General Sherman is in the prime of life, showing little sign of deterioration. If conditions remain favorable, it may survive for another 3,000 years.

"This Land" highlights the biological phenomena of the 153 U.S. national forests. Robert H. Mohlenbrock is professor of botany at Southern Illinois University at Carbondale.

Most English farms were enclosed between the fifteenth and eighteenth centuries. Only Laxton, in the Midlands, escaped the enclosure movement, perhaps because of its relative isolation.

The Observer, London

Laxton's Open Fields

Neither fences nor hedges divide one person's land from another's—a system of farming that dates back to the Middle Ages

by Donald D. Donihue

When Richard Rose sets out to plow his father's land in the West Field at Laxton, it takes him all day. Not because his father's holding is so great that a full day's labor is required—there are only five and a half acres—and not because of antiquated tractors and farm machinery. It is, rather, the consequence of the peculiar way in which the land is worked by Laxton farmers—a pattern that goes back before the Middle Ages in England and northern Europe. As Richard's father says, "We've grown accustomed to working it that way."

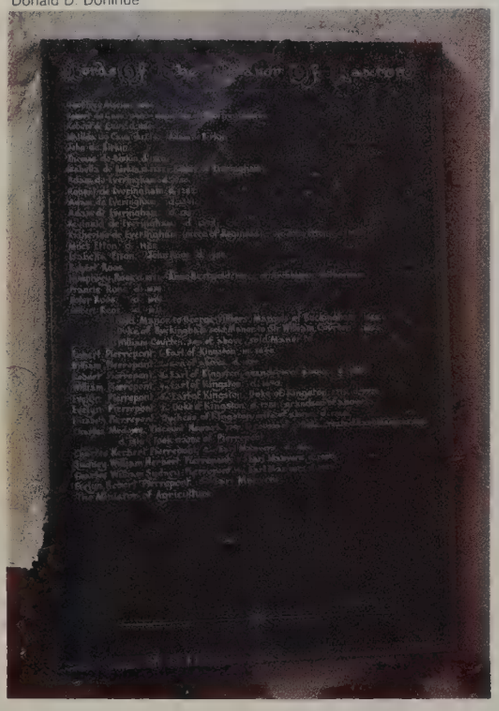
Many fields in the English Midlands used to be vast and open; neither fences nor hedges divided one person's land from another's. Gradual enclosure of the open fields began in the fifteenth century, transforming English rural society. By the last part of the eighteenth century, when the Industrial Revolution was almost complete, the English countryside had turned into a landscape of smaller fields, hedges, stone walls, and scattered farms. Thousands of people moved from farming villages and crowded into cities like Nottingham to find employment.

Only one village in England escaped the complete enclosure of its open fields: Laxton, about an hour's drive from Nottingham and reachable only by a network of narrow roads. One of the reasons for its survival as an open-field village is its very isolation. Only here in Laxton do English farmers still tend their fields according to rules formulated by neighboring farmers during the Middle Ages.

Life in Laxton today, with its population of 280, is not very different from life in any small village community of the Western world in the late twentieth century. The John Deere Company is a familiar supplier of basic farm implements. There is contact with the outside world through television and through children who have taken up life in more economically rewarding places. A number of residents commute to work in nearby towns or coal fields. Children are bused to school in neighboring villages. Farmers are always on the lookout for additional income, and this may mean active participation in agricultural schemes of the European Com-

A tablet, mounted on the back wall of a church in the village, lists all of the lords of the manor, from the eleventh century to the present time.

Donald D. Donihue



mon Market. And modernity has made its way into the heart of the village in many other ways. Only the manner of working the land seems caught in a time warp, unable to let go of the Middle Ages.

To be sure, there are a number of silent reminders of the past as one walks down the streets of the village. For example, one barn, constructed out of brick, has the date 1760 built right into the brickwork, while farther down the street, a house of the same kind of construction is dated 1748. On the north edge of the village, where the land rises, one finds the remains of a motte and bailey castle (a primitive type of castle built on a hilltop)—one of the many that dotted the English countryside during the reign of William the Conqueror in the eleventh century. Today all that survives of the castle is a mound of earth and portions of the ancient rock wall breaking out of the earth.

The most striking feature of Laxton today is what surrounds the village on three sides. Here three great, open fields—the West Field, the Mill Field, and the South Field—continue to be the source of livelihood for farmers and their families. Over a three-year period, crops are rotated among the fields, just as they were in the Middle Ages. In a given year the West Field is planted in winter wheat, the Mill Field is the fallow field, and the South Field is sown in spring corn. During the following year, the West Field will be the fallow field, the South Field will bear winter wheat, and the Mill Field will bear spring corn. And so it continues, year after year, as it has for centuries.

There is another medieval pattern that the farmers have not relinquished—and that is the manner in which land is held in the common fields. A family's holding is not all in one place in any one field. Instead it is scattered among all three open fields in narrow strips. Bill Haigh, who runs a dairy on Manor Farm in Laxton, will tell you:

> I have land in all fields—all three fields. I have three in South Field, and I have four in Mill Field, and I have just one in West Field. That's what my open field land is; so I've around twenty-seven acres.

Haigh's situation is typical of the eighteen farmers who have holdings on the Laxton estate. To the modern eye, it is an extremely awkward and ineffective way of holding land. That's why it takes so long to plow and harvest one's acres. One of the farmers remarks (but without complaint): "There's all that equipment to move around from strip to strip."

This peculiar style of holding and working the land forms a continuous thread between previous centuries and the present. A map of Laxton, drawn in 1635 by Mark Pierce and now housed in the Bodleian Library at Oxford University, depicts how farmers worked—and still work—their scattered strips of land. Pierce also illustrated the closely knit social life of the villagers—plowing together, harvesting together, herding flocks together, and even stalking the wild deer on the Laxton estate together.

The farming year at Laxton is built around the three open fields. The year begins in the fall, with the sowing of the winter wheat field. At the same time, the field that is to be planted with corn in the spring is plowed. The third, or fallow, field is open to sheep, so that they can graze on the stubble of the preceding year's crop. The fallow field is the counterpart of the common field of previous centuries, the

Every autumn, a field jury inspects and redefines the boundaries of the farmers' strips, making certain that no one has encroached on the holding of another.

Donald D. Donihue

Right: A heavy wooden stake, hammered into the ground by a field jury member, will designate the line between a farmer's plowed strip and the grassy pathway that is meant for use by everyone.
Below: Laxton farmers take great care not to plow too far onto the grassy paths—although even without markers, the farmers know the boundaries of their individual strips.

Both photographs by Robert Holmes

place where livestock of the entire village could be let out to graze. "Breaking" the field used to be a big event in medieval villages. When all the crops had been taken from a field at the end of harvest, the church bell would ring on a set morning, and everyone would know by the sound of the bell that sheep could be grazed on the common field.

We see in the fallow field one of Laxton's adaptations to modern times, however. No longer does the field lie fallow the entire year as it used to when a rigid three-course rotation was in effect. In 1968 the village voted to "crop" the fallow field, permitting tenants to grow a fodder crop there. In many ways this made much sense, because it was no longer necessary to idle a field in order to allow it time to gather strength to bear another crop. Modern fertilizers and farming methods had rendered obsolete the inflexible three-course rotation and it was not economical to continue the practice. But the change came slowly and with difficulty—a rare giving-in to modern times.

The plowing of these scattered strips is an interesting sight. Each farmer moves his tractor off the grassy pathways, or sykes, leading through the fields and onto his strips. Great care is taken not to plow too far on a strip, thereby encroaching upon another's land. One must also be careful not to plow too far onto the headlands and grassy roadways, thus diminishing over the years those access routes that are meant for use by all.

In early November, seed is sown in that year's wheat field. By the end of the month it will be a sea of green shoots sweeping across the rising and falling open field. Also at the end of the month the wheat field will undergo an annual inspection by the members of the field jury to assure that all the boundaries are intact and that no one has encroached on the holding of another.

Winter snow can be deep in Laxton. The pace of life slows. Still, there are cattle and other livestock to be fed and cows to be milked. Spring brings a renewal of activity. Ditches have to be cleared of brush, and cattle that were fattened over the winter must be taken to market in nearby Newark-on-Trent. The grass on the pathways of the fields grows again. On a midsummer's day it will be sold to the highest bidder at an auction in the village, as has been the case since the 1780s. Harvest follows in the summer, when machinery moves into the fields and onto the strips. What used to take weeks is now done in a matter of days. Wheat is separated from chaff and sent to storage.

When the harvest is done, the field that bore the year's wheat crop is open again to livestock, which forage among the stubble. The year has come full circle.

The management of the Laxton estate is similar to that of many large agricultural enterprises. The tenant farmers pay annual rents to the landlord, who in this modern age is not an individual but a corporation, the Crown Estate Commissioners. Running the estate is a joint landlord–tenant operation. Permeating this relationship are the rules of the open fields that have evolved across the centuries. Such rules assure the rights of the tenants to their lands, the continuing sequence of crop rotation, and the care and upkeep of the sykes. These rules are enforced by one of the few surviving Courts Leet in England. Meeting each December, the Court Leet (a basic political unit of the village) at Laxton enforces fines levied against tenants who have plowed outside the boundaries of their holdings in the fields or left rocks or trash on the sykes.

A major responsibility of the Court Leet each year is to swear in the twelve members of the field jury who annually inspect the open field sown in winter wheat. Beginning early on an autumn morning, all twelve members walk along the entire open field, inspecting the boundaries of the strips and sykes.

Edmund Rose is bailiff for the village and is responsible for convening the Court Leet, organizing the field jury, collecting fines, and enforcing the rules of the open fields. His father held the office before him. Today Edmund Rose is just one tenant farmer, but in the sixteenth and seventeenth centuries his ancestors (by the name of Roos) were lords of the manor and owned the entire estate. So Rose's roots run deep into Laxton's past. As he approaches retirement, Rose wonders how long Laxton will last in its race against a post-industrial age. His love for the village is plain when he says:

It's not one of the most economic ways, but it's our little part of England. And we are proud to uphold the traditions that our fathers upheld for us. And given the good will of the landlord to us as tenants, we can see our children continuing it.

Laxton's medieval ways do not extend beyond its open-field system of agriculture. Farmers use modern machinery, such as this combine.

Robert Holmes

Because a farmer's holdings are not contiguous, he must move his tractor and machinery from strip to strip, a time-consuming method of working the land.
Robert Holmes

Why does Laxton survive? Why did it not go the way of all other English villages in the East Midlands? Answers to this searching question come in geographical, sociological, and economic categories.

First, the geographical. There is the isolation of the village—it is clearly off the beaten track, lying midway between two major highways that run north and south in England—the A-1 and A-614. Even today the primary interest of the villages between these two trafficways is agriculture, and the landholding pattern at Laxton has continued to serve the interests of its residents.

What is more, for Laxton and the villages that surround it, enclosure came late compared with the rest of England. When it did come, new drainage schemes often had to be devised at a heavy cost to the owners. At Laxton today we can see the way strips were laid out in harmony with the natural fall of the land. Those areas that were poorly drained through the centuries are the sykes of the fields today. To have changed the contour of the land in the mid-nineteenth century would have come at a substantial price to the new owners.

Sociologically, tradition has a firm grip on Laxton, as Edmund Rose has indicated. Tradition, as defined by the Ger-

Below: The view from the church tower shows the road that leads from the village out to the West and Mill fields. At right, cattle graze on private property. Many farmers augment their income by cattle rearing or by dairy farming, activities that allow them the luxury of continuing a method of farming that is not cost effective.

Both photographs by Robert Holmes

man sociologist Max Weber, is "everyday routine as an inviolable norm of conduct." For the farm families at Laxton, conceiving of the open fields as converted to compact blocks of land or as one great, corporate farm is next to impossible. The community spirit they enjoy is part of their tradition, and the grouping of their homes in the village encourages that spirit. Simultaneous activity—all plowing at the same time, all sowing at the same time, all harvesting at the same time—contributes to community spirit as well. Furthermore, there is a rare intimacy with the land. Even though there are no markers, the farmers know the boundaries of their strips as well as they know the backs of their hands. Bill Haigh tells a newcomer:

> I could take you onto the Mill Field, and it would all look alike to you. But I could point out where all the boundaries are to within a yard.

In many ways their lands are extensions of their very selves.

Finally, there are economic reasons for Laxton's survival. In terms of the larger economies of scale, there is little, if anything, cost effective about Laxton's agricultural system in its present form. Estimates project that farmers would earn up to 20 percent more with normal, contiguous fields. But most have other agricultural projects in addition to their land in the open fields—projects such as cattle rearing or dairy farming. When all these enterprises are put together, a modest livelihood becomes possible. No one is getting rich from the system, but survival is possible in a way of life that is all Laxton farmers have ever known.

What about the future of Laxton? It is no secret that from 1952 to 1981 Laxton had a most sympathetic owner and landlord: the Ministry of Agriculture. While tenants paid rents to the ministry, there was a continuous backlog of repairs, the cost of which was not offset by the rents. It was costing the Conservative government of Prime Minister Margaret Thatcher $30,000 a year to maintain the village's forty houses and farm buildings. As a result, the village and open fields were put up for sale by the government.

No one anticipated the public outcry that resulted. Conservation groups, academic experts, and even unions protested the relinquishing of England's last open-field village. Joan Thirsk, an economic historian at Oxford, likened the selling of Laxton to the dismantling of Stonehenge for the building materials it contains. So the ministry sought a buyer who could be relied upon to do nothing to jeopardize the open-field system of farming. In May of 1981 such a buyer came forward in the form of the Crown Estates Commissioners, a complex department that administers the property owned by Queen Elizabeth personally and not by right of being the sovereign. Revenue produced by the Crown Estates is subsequently turned over to the government in exchange for the support of the royal family. It is a strange and ironic mixture of aristocratic/bureaucratic landholding that will determine the future of Laxton.

If the commissioners' record since their purchase of Laxton is any indication, the village's immediate future appears bright. Rents were raised according to schedule a year and a half ago, but only after assessing the extent to which Laxton's farm families had maintained and improved their holdings. Drainage projects are under way in the fields, and the farmers are taking part in each stage of the process. Adding to the village's present optimism have been bumper wheat crops in 1982 and 1983. The 1984 crop, which was still in the South Field at this writing, looked equally promising.

The big fear, of course, has been that over time the commissioners would discontinue the open-field system and join the strips into one large farm. Just the opposite has been the case. When one farmer died not long ago, his strips were redistributed among other farmers, but only with great care so as not to violate the centuries-old rule that no two separate strips in the fields would be joined by a farmer's acquiring a third strip.

The key to survival for this village that won't let go of the Middle Ages lies in the ability of its farmers to adapt to changing circumstances. A kind of pragmatism governs Laxton farmers in that process of adaptation. Ernest Kent, who took up Ide Farm in the 1950s, summed up the new relationship between landlord and tenant when he said recently, "They've got us, and we've got them. So we'd just as well work together to make the best of it." That same pragmatism joins with a sense of history among Laxton farmers to perpetuate what they consider to be the native values of rural life. □

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Knockouts in the Nest

Sibling rivalry can have fatal consequences for great egret chicks

by Douglas W. Mock

The egret chick was under attack. Its nape was nearly bald from days of repeated assaults by its two older siblings, and the back of its head oozed blood. Now flailing its quilled wing stubs for extra support, the young egret pumped its gangly legs, seeking new toe grips in the branches of a bush just outside the nest. It took another sharp blow to its neck and moved faster as an older sibling followed it over the rim of the nest.

Usually, the older egret chicks, one and two days senior to the chick under attack, abandoned their assaults when the younger chick fled the nest, but this time things were different. With a loud squawk, one senior landed a dozen solid shots on the junior's skull, causing it to plunge forward once more. Losing the grip of one foot on the main bush limb, the victim reached out futilely with the toes of its other foot. It fell eighteen inches and dangled upside down, low in the bush. Although there was dry grass just three feet below, the fall would probably mean death for the bird, either quickly from predators or slowly from exposure and parental neglect. (Parent egrets seldom tend their offspring outside the nest.) Three days without food (because of attacks by its older siblings) had left the chick weak and dehydrated. Nonetheless, it thrashed and swayed frantically for a few minutes. At last it let go, dropped to the ground, and lay motionless but still alive. By the following dawn, it would be taken by a predator.

Seventy-five feet away, I watched the drama unfold and dictated the events softly into a tape recorder. My assistants and I had seen such struggles before and would see them again in the next few summers. By rotating observers in our large plywood blind in the center of this egret colony, we had maintained a constant vigil over this nest—and fourteen others—for several hot and sticky weeks. We had come to Port Lavaca, Texas, on the Gulf of Mexico, for four months of each year from 1979 to 1982 to study siblicide—the killing of a sibling—certainly one of the most extreme forms of selfish social behavior.

The theoretical importance of siblicide is linked to W.D. Hamilton's concept of

A pair of great egrets exchange nest attendance duties.

Jeff Foott

Douglas W. Mock

A great egret chick that is only one or two days older than its sibling may intimidate, attack, or even kill a younger nest mate in the vicious competition for food. In this sibling fight, the older (and taller) chick has landed a blow that snaps its opponent's head backward.

inclusive fitness, which depicts evolutionary success (total genetic contribution to future generations) as a combination of the individual's own lifetime reproductive success plus specifiable fractions of that achieved by its kin. This second avenue, the indirect component, has generated much of the sociobiological excitement of recent years because it offered a means of evolving altruism and cooperation via what has come to be called kin selection. This logic might look at two vertebrate brothers, for example, and note that an average of 50 percent of their genes are identical through common parentage: a nepotistic favor by one would thus reward the performer's own genes, albeit indirectly.

Relatively little attention has been paid to the flip side of that logic, that the half-full glass of water is also half-empty. Because the individual always carries twice as many of its own genes as it shares with even a full sibling, there must be occasions when nepotism takes a back seat to self-preservation. That form of selfish behavior is what I wanted to study. I wanted to learn why spectacular and destructive actions had evolved in ardeids—the family of long-legged wading birds that incorporates egrets, herons, and bitterns—and what ecological factors influence such behavior today.

Ardeids typically lay more eggs than can survive, and unlike most songbirds, they don't hatch their eggs simultaneously but at one- to three-day intervals. Because incubation starts while laying is still under way, the chicks hatching from the earlier-laid eggs have a substantial head start in development, often possessing an insuperable advantage over their siblings.

In the 1940s, British ornithologist David Lack proposed that such a pattern of incubation and hatching enables the female parent to hedge her bets. She must commit herself to a specific number of eggs early in the spring, yet she cannot know whether there will be enough food when the chicks' need for nourishment peaks several weeks later. If the season turns out to be rich in food, all nestlings may fledge; but if it is poor, the younger chicks are likely to starve first, thereby enabling parents to raise the maximum number of healthy offspring in spite of an unpredictable environment. Such brood reduction is a lethal game of musical chairs—one in which the first-hatched players usually have substantial advantages of size, strength, and coordination.

The role that overt aggression might play in such situations has not been well understood, despite the many recorded anecdotes of sibling fights among nest mates. In a few eagle species, for example, one chick invariably kills its only sibling. But most of those species nest in such isolation that it is difficult to undertake quantitative field studies. Our 1979 discovery that great egrets in Texas often kill their nest mates provided a good opportunity to make just such a study. We hoped that what we learned about these egrets would prove generally applicable to other, less accessible species. We decided to compare great egrets, which we knew often killed their siblings, with neighboring great blue herons, which, it seemed, did not.

Our method was to keep a vigil over wild broods, recording everything pertaining to aggression and the distribution of food. Because both these bird species nest in the same colonies and the relevant events occur only sporadically, we could keep accurate records on as many as fifteen nests at once throughout the first month after hatching. Team members rotated in and out of the blind in twenty-four-hour shifts and were replaced quickly during the colonies' quietest mid-afternoon period. Thus an observer would enter the blind at 3:00 P.M., record until 9:00 P.M., sleep until 6:00 A.M., record until 3:00 P.M., and then return to a rented house on the nearby mainland.

To supplement this detailed information, we also visited hundreds of nests in other nearby bird colonies in Lavaca Bay, stopping at each nest for only a few seconds every fourth day to see how the dye-marked nestlings were faring. To document the effect of sibling aggression on growth, we took standard size and weight measurements at sixteen egret nests. In the first year of the study, we also hand-raised six broods of captive egrets in a crude aviary—chicken wire wrapped

around the support poles of our rented stilt house. We studied growth and development in this group, an exercise that provided us with a provocative and serendipitous clue to the puzzle of siblicide.

Sibling aggression is an important aspect of survival in great egret broods. The members of all observed nests repeatedly fought hard throughout the first month, with the larger siblings generally initiating the attacks and almost always winning. In three-chick nests, for example, brood mates fought an average of 109 times during the first twenty-five days after hatching. Deaths caused by siblings were common and affected the youngest and smallest disproportionately. The older, larger chicks typically dominated and acquired more than their share of available food, initially by being stronger and faster, later by intercepting the food supply. This advantage inexorably worsened the runts' survival chances. About half of the youngest nestlings died in the first month, and most of those deaths were apparently hastened by the senior chicks.

To our surprise, aggression did not decline when food was abundant. The six captive broods, which we fed three times a day (providing considerably more food than parents do), continued to fight. Two wild broods, given food bonuses every day, also fought viciously. Sibling aggression seemed to be relatively inflexible, though eventual survival of the youngest egret chick may be determined by the total amount of food received. If the parents manage to deliver lots of fish, the youngest chick may get enough food to withstand the beatings it gets.

The great blue heron chicks were far less aggressive than the egret nestlings. Many broods never even had one fight, and sibling aggression almost never seemed to contribute to fatalities. When the youngest heron chicks died, the cause was generally slow starvation.

In observing the feeding behavior of egrets and herons, we were looking for clues to explain the differences in aggression between the two species. Great egret parents in Lavaca Bay typically feed on very small fish—menhaden and silversides—with an average length of two

Joni James

Small fish—weighing a fraction of an ounce each—are typical prey for great egrets, below. During the first week, when the egret parents deliver this food to the nest floor, all siblings in the clutch have a chance to scramble for a meal. Later, the feeding methods shift, and aggression becomes a key to monopolizing food. In Texas, great blue herons, right, catch relatively large fish—more than one hundred times the weight of egret prey. Perhaps because fighting doesn't help them monopolize such huge food items, Texas heron chicks are less aggressive than their egret counterparts.

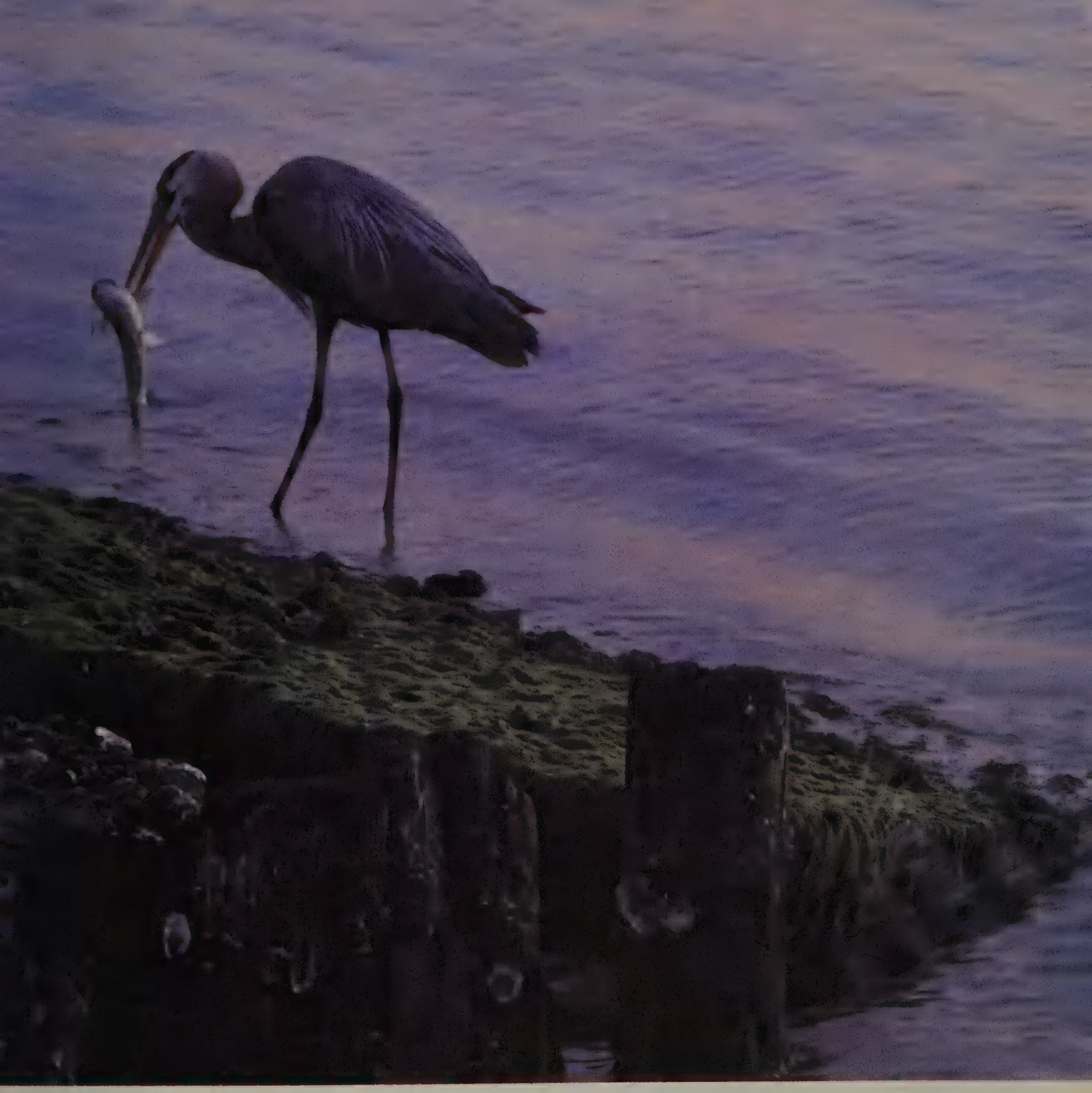
Brian Milne; Valan Photos

inches and weight of only 0.07 ounces. They capture and swallow many of these fish in the shallow marshes around the bay, then fly back to the nest, where they present the food to the chicks as regurgitated boluses (tidy little wads of whole fish held together with saliva). During the first days after hatching, parent egrets regurgitate the boluses onto the nest floor, and the chicks race to grab them. Such feeding contests, which ecologists call scramble competitions, put a premium on speed. The egret nestlings quickly acquire skill in this competition; the mean time for grabbing a bolus drops sharply from about six seconds at hatching to about one second by ten days of age. So steep is this curve that even a one-day difference in age can result in as much as a 31 percent reduction in time, which means roughly one-third more food consumed if the supply is small. Older nestlings thus gain a feeding dividend from their age advantage. Even though the nestlings have already begun to fight, relatively few of the youngest chicks are so intimidated that they miss any meals during this early phase of their development.

When egret chicks are nine days old, however, their behavior changes radically. At that age, they alter the nature of their food competition. Senior chicks begin to intercept the boluses before they reach the nest floor. Now the chick scissors the parent's bill with its own. Then, sliding its bill up and rolling it under the open corner of the parent's mouth, it catches the bolus as it falls out. This technique enables one chick to monopolize the whole bolus before it lands on the nest floor.

The contests for food, accordingly, shift from gobbling food off the nest floor to jockeying for a position in front of the parent. At this point, any junior nestling that can be intimidated to even a slight degree can be excluded effectively from the food. Now boluses are more likely to be acquired and kept through aggression. The siblings continue to fight, and the already established dominance of senior over junior is maintained. And because parents bring an average of only two and a half boluses per feed (either this is all they can catch or they keep some for themselves), the share of food going to the oldest nestlings grows while the share going to the youngest dwindles.

By contrast, great blue heron parents provide their young with another sort of prey. They feed their chicks huge fish, mostly mullets, about five times longer and one hundred times heavier than the prey of egrets. After one of these fish is regurgitated onto the nest floor, heron chicks peck at the softened front end, which has been partly predigested by acids in the parent's stomach. No heron nestling can monopolize these meals because—for several weeks at least—it is incapable of hefting and swallowing such large fish. Accordingly, intimidation among the siblings is less effective. After the chicks have chiseled off the softened tissue, the attending parent reswallows whatever remains of the fish. The fish is again "cooked" in the parent's stomach acids for another half hour or so, then regurgitated once more. This process may be repeated three or four times—during which the fish shrinks like a bar of soap in the shower—until the last of the tail can be gulped down whole.



These observations led me to suspect that the size—and perhaps not the amount—of the food offered to newborn chicks might be an important key to the intense sibling aggression seen among some nestling birds. According to the literature on other siblicidal bird species, food size does indeed correlate with highly aggressive nestling behavior across a broad range of birds. Young eagles, owls, ospreys, and skuas are fed on small bits of food torn by the parents from large prey before presentation. Young pelicans, kittiwakes, and boobies take either small or predigested food directly from the parent's mouth. These birds are also siblicidal. In oystercatchers and grebes, where sibling aggression but not siblicide is known, food is likewise small enough to be monopolized.

In the spring of 1982 another team and I returned to Lavaca Bay to test the prey-size hypothesis with both egrets and herons. If large prey really do promote pacifism in great blue herons while small prey promote siblicidal aggression in great egrets, what would happen if each species were reared on the opposite type of diet by foster parents? We knew that these birds, like many species that nest in colonies, cannot recognize their young until several days after hatching. In 1981, a pilot study on one nest had shown that egret parents accepted a heron brood readily.

To carry out the experiments, we moved ten three- or four-egg heron clutches to egret nests and vice versa. We then observed the feeding and fighting in all the nests, which we compared with data previously recorded for normal broods. To eliminate possible complications from the fact that heron chicks ordinarily receive greater amounts of food from their natural parents than they would from the foster egret parents, we gave four of the heron broods a daily bonus of small fish, equal to about 30 percent of the foster parents' delivery. (It turned out that this, like the supplements we had given to egret chicks, had no measurable effect on aggression.)

The results of the experiment were dramatic. The heron chicks raised by foster egret parents on tiny units of food fought

In a field experiment, egret chicks were raised by great blue herons. Below: An egret chick persists in its vigorous attempts to intercept a food delivery, although the fish brought by its heron foster parent is too large for it to swallow. As the adult tries to reswallow the fish for further digestion, the chick hangs onto the tail of its potential meal.

Douglas W. Mock

from the start. Furthermore, they quickly acquired the habit of scissoring the "parent's" bill and taking the boluses directly. As in the natural egret broods, the growth of the youngest cross-fostered heron chicks fell behind when they were competing for the indirect feeds. After the switch to direct feeds, these chicks were effectively intimidated. By the twenty-fifth day, eight junior heron chicks were dead, six as the victims of siblicide. (The youngest chick in one brood was still alive and one had failed to hatch.)

The second part of the experiment was more puzzling. The young egrets that received large-sized food in the heron nests also fought quite a bit and tried to feed by scissoring the herons' bills after a week and a half or so. These attempts were catastrophic: A young egret trying to scissor a heron's bill during the passage of a partly digested fish was often pinned to the nest beneath a gargantuan mullet and matted with fish mucus and heron saliva. The fostered egrets remained thin and weak and many seemed incapable of knocking much food off the proffered fish. Seven of the egret chicks died. Because aggression had continued and presumably contributed to their deaths, they too were counted as victims of siblicide.

It would therefore seem that great blue herons show flexibility in developing aggression against their siblings and that this behavior can be elicited by the size of the food. But the interpretation of the behavior of egret chicks is not yet clear. Although they do not always kill their junior siblings, they seem to be less flexible in terms of their intra-nest fighting. I can offer several possible explanations for why more flexibility evolved in herons than in great egrets. Perhaps the bay in Port Lavaca, where we did our field research, offers two general sizes of fish, tiny and huge, and the egret adults are too small to exploit a supply of giant fish. Certainly, egret chicks seem too weak to carve off sufficient food from large carcasses.

Another explanation might be that both great egrets and great blue herons inhabit a wide geographic range. Great egrets live throughout the tropics; great blue herons are found across most of North America. Perhaps populations of both species that live in areas where small fish predominate are commonly as siblicidal as the Texas egrets. Perhaps parents in habitats that have both large and small prey can influence sibling conflict by their choice of food. Despite all the research, one provocative question lurks in the background: Why don't parents of siblicidal ardeid chicks intervene and stop the mayhem? □

After nine days of life, great egret chicks no longer scramble for food on the nest floor. Competition and aggression intensify as nestlings start to take food directly from the parent's bill.

Jeff Foott

young porcupine scales an oak tree in central Michigan. Porcupines climb trees by raddling them and hoisting themselves with their claws. The tail is pressed against e trunk to check downsliding.

n Shaw

How to Select, Climb, and Eat a Tree

essons from the porcupine school of forestry

y Uldis Roze

In a forest on a clear summer night, one n sometimes hear a sound like soft rain lling. But the light drumming on leaves not caused by raindrops; it is the sound caterpillar droppings tumbling down rough the canopy. Human ears cannot ck up the noises caterpillars make when ey feed—the tiny gnashings of caterpil- jaws, the scratchings of caterpillar feet er leaves.

When I am in the forest and imagine ch things, I also imagine other sounds—chorus of *ptuis!* and groans, as disgusted terpillars spit out foul-tasting leaves at they've chewed a minute too long. For ees have weapons against the caterpillar, isonous or unpalatable food additives, digestible structural materials, and poor trient packages. The forest is a tough ace for an animal to find a meal. The earest evidence of this is the small nount of living biomass consumed by rest animals every year.

One animal that manages to make a ccessful living in the forest is the North merican porcupine, *Erethizon dorsa- m,* which has physical as well as behav- ral adaptations that permit it to live its e as a tree feeder. In my seven years of udying porcupines in the Catskill Moun- ins of New York State, I have found em to be a good match for the overlap- ng and often subtle defenses erected ainst them by the trees.

Like all of North America's human ock, the porcupine is an immigrant. It rived on this continent fairly recently, th the final establishment of the Pan- na land bridge some two million years go. Its closest relatives are Central and outh American porcupines of the genus *oendou.* These animals are so highly lapted to life in trees that they are sel- om observed on the ground; conse- ently, very little is known of their natu- l history. It is this arboreal heritage that *Erethizon* brought with it to the new continent.

Although the North American porcupine can walk considerable distances on the ground, it is at its best in a tree; seeing it up there you realize what an agile and coordinated branch walker it is. How does a short-limbed, quilled animal like a porcupine get into a tree in the first place? Its method reminds me a little bit of a telephone company linesman. The porcupine sinks its claws into the bark and scales the tree straight up, moving deliberately and testing its hold at every level. The animals prefer rough-barked trees, whose crevices offer a nice fit for the claws. They use certain trees over and over as resting spots; the bark of these trees takes on a scuffed, abraded quality.

The tail, a powerful and versatile appendage, also helps in climbing. Its underside is covered not with quills but with stiff bristles that point down. These are set in thick connective tissue. Like a woodpecker, the porcupine uses its tail to check backward sliding, pressing it hard against the trunk of a tree. In effect, the tail is a fifth leg that the porcupine can use for climbing and descending; but it lacks the prehensile properties of a monkey's tail or the tails of South American porcupines.

Porcupines prefer trees with rough bark, but they are perfectly competent at climbing smooth trunks as well. To do so, the animals turn their large, naked footpads inward and grip the trunk through frictional force alone. Tuberosities on the footpads help them do this. Porcupines have powerful clenching muscles in their thighs, and they can press their footpads so firmly against a small trunk that an individual animal can hold on without using its forelimbs. Males tend to have larger footpads than females, possibly because they are generally heavier.

Up in the canopy, the porcupine moves confidently from branch to branch, sensing the substrate and conforming to it with its footpads. One can seldom observe the animal in this element, however, because it is almost always a nocturnal feeder and remains hidden in the foliage.

I watched one porcupine feeding in the canopy on a May night in 1983. The animal had climbed into a young beech tree whose leaves had so recently opened that the tree seemed transparent. I could see the animal well—a full moon threw the porcupine's round shape into dark relief. It moved ceaselessly through the branches, harvesting the nutritious leaves. Sometimes the body hunched into a tight ball; sometimes it stretched out into a vertical clinging mass, then moved out again toward the tip of a branch. A brisk wind was tossing the branches, carrying the porcupine in heavy arcs through the sky. Yet the animal never stopped feeding; at times it seemed to reach impossibly far to snag neighboring branches and bring them into feeding range. Over the modulations of the wind, I could hear the faint sounds of leaf crunching from the dark rider above me.

Beech trees have tough, almost unbreakable, branches, but other tree species on the porcupine menu are not so hardy. Aspens, for example, crowd their most nutritious leaves at the tips of branches that are too thin and brittle to carry the weight of a seventeen-pound animal. The porcupine seems to have a good idea of the difference between a modest risk and sheer folly, however. To harvest terminal leaves, the animal invokes the elegant technique of "nip twigging." This method is simple: From a safe perch, the porcupine gnaws off the end part of the branch, then holds it in its paws and consumes the leaves in safety. The bare twig is thrown away.

Porcupines may be savvy at judging what a limb will put up with, but perhaps

Uldis Roze

In winter, porcupines eat mainly tree bark, and sometimes they are extremely picky about which trees they eat. At right, a lone beech tree in the Catskill Mountains of New York has been stripped of all its bark, while others around it have not been touched. In early spring, porcupines abandon the bark, which is not very nourishing, and move on to greener parts—the catkins of quaking aspen and the leaves of sugar maple, beech, and white ash. The porcupine below is drowsing in an aspen in April.

John Shaw

inevitably, there are miscalculations. The animals can and do fall out of trees, though the result is rarely fatal. Perhaps the most compelling evidence for this comes from an examination of animal skeletons taken from the wild. When I examined fifteen adult skeletons in two museum collections, nine showed evidence of healed fractures. Five juveniles showed no evidence of injury; perhaps they fall less often because their lighter weight puts less strain on a branch and their periods of exposure have been shorter. The commonest injuries I saw were broken ribs, but I also found a broken hip, a broken tibia and fibula, and breaks in a sacrum and a humerus. In all cases, the bones had healed.

Broken bones may represent only a small fraction of the injuries, though. Animals falling into snow or through low branches may not hurt themselves. Yet in all such falls, you might think a porcupine risks impaling itself on its own quills. One of the more surprising findings of my work has been that the animals have developed a mechanism to protect themselves from just such a calamity. The quills, I have found, contain an antibiotic.

I discovered this after a work-related mishap in September 1983. I was trying to capture a powerful male that I had followed up into a tree when the animal drove a quill deep into my upper arm. To my horror, the entire quill disappeared under the skin. Over the next two days, it traveled downward through tissues in my arm and elbow, causing me intense pain at times. Then, while I was teaching a class, I felt a scratching inside the arm of my shirt. The quill had emerged from my lower forearm completely intact. What I found remarkable was that for the entire course of its travel it had started no hint of an infection. I mentioned this story to Ward Stone, chief wildlife pathologist of New York State, and he suggested looking for antibiotic activity on the quills.

This suggestion turned out to be apt. When I made an extract of porcupine quills and tested it against bacteria, the extract slowed bacterial growth. The antibiotic has not been chemically characterized, but it appears to be a novel fatty acid. As expected of a fatty acid, its antibiotic activity is relatively mild. What this means is that porcupines carry a medical insurance policy against their own most formidable weapon, their quills.

Getting up into a tree and staying there is just the first step in finding food. The porcupine must be able to eat, digest, and metabolize the tree products it gathers. Here the evolutionary battle between the trees and the herbivores escalates. The

porcupine approaches tree feeding with impressive structural tools.

Winter feeding for porcupines means bark feeding; tree bark is their main source of sustenance, and it's not a tender dish. When feeding on beech and sugar maple, the porcupine must shave thick bark twice. The first pass removes the dead outer layer, and the fragments are allowed to fall in the snow below. A second pass shaves off the living inner bark; the porcupine grinds this up with its cheek teeth and swallows it as a fine purée. All of this involves a good deal of noisy chewing; but a porcupine's rootless incisors, hardened by orange iron salts, cannot be worn down by an entire winter of bark feeding.

Extracting nutrients from the chewed bark is facilitated by a body that is dedicated to digestion—about 75 percent of the porcupine body cavity is taken up by stomach, caecum, and intestines. The caecum is a large sac, filled with microorganisms, that resembles the rumen of ruminant herbivores. It converts otherwise indigestible carbohydrates into metabolizable fatty acids and contributes significantly toward total energy requirements.

But in spite of this large and efficient digestive system, the animal loses weight during the winter. The inner bark of trees contains a very low concentration of nitrogen (needed to build proteins) and an excess of indigestible roughage. The roughage limits the rate at which food can be processed, so porcupines can't compensate for the low nitrogen content of their food by eating more. Though their digestive tracts are always full, the animals are physiologically starving.

For example, during the winter of 1983–84, the porcupines in my study population lost an average of 17 percent of their body weight. One male had lost this much by mid-February. It became listless and unresponsive, allowing me to practically touch it before it erected its quills. Over the next two weeks, this animal lost an additional 17 percent of its weight. I found it frozen to death on March 3. Yet an autopsy showed that its digestive tract had been full.

Porcupines cope with the dietary stresses of winter by reducing their diet

Some trees on the porcupine diet crowd their best leaves at the tips of branches. To harvest this elusive crop, the porcupine chews off the part of the branch that is too delicate to hold its weight. It then takes this piece in its paws and leisurely eats the leaves. This "nip twig," such as the bare linden twig below, is then thrown away.

Uldis Roze

breadth and minimizing their movements. Each animal feeds on only one or two species at a time, while the total population feeds on eight to ten different species. The narrower diet may include the one or two tree species most easily digested by a given animal's microorganisms. When an animal is starving, even a slight increase in digestive efficiency may spell the difference between demise and survival.

Another strategy is to select winter foraging areas where preferred trees are abundant. By doing so, porcupines reduce travel time and exertion in the snow. In deep snow, the animals end up dragging their bellies since they can't get firm footing; this creates feeding trails that look like the work of giant centipedes. Porcupines have other tactics for minimizing snow travel: They move back and forth in their own footsteps and travel in the shelter of rock overhangs. But most important, they move less: Their winter ranges in the Catskills average only 12 percent of their summer ranges.

As the winter snows melt in April and May and spring peepers begin calling in the dusk, porcupines burst out of their dens. Trees begin pouring nutrients into emerging leaves, and porcupines quickly abandon the bark for this incomparably richer diet. Whereas tree bark averages only 2 to 3 percent crude protein, spring foliage may contain more than 20 percent on a dry-weight basis—richer than the "enriched" cereals available to humans.

That it is the high protein content of young leaves and buds that attracts porcupines is suggested by their feeding methods. Their discarded nip twigs show they feed on the leaf blades alone, rejecting petioles and branch tips. Nitrogen analyses of the leaf blades show that protein levels are three to five times higher than those of the petioles. In early spring, porcupines are similarly choosy in bud feeding. Individual buds are neatly excised (crude protein in excess of 20 percent); terminal twigs are discarded (crude protein 7 to 9 percent). At this time they forage on sugar maple (buds and leaves), beech and white ash (leaves only), and the catkins of quaking aspen.

However, the trees are rallying to defend themselves. As spring eases into summer, the trees accumulate tannins in their leaves, polyphenolic compounds that alter proteins and inhibit the porcupines' digestive processes. And by mid-June, the porcupines have once again moved on to a new diet, this time the tree species that will last them till leaf drop. Most important of these are American linden (*Tilia americana*), quaking aspen (*Populus tremuloides*), and bigtooth aspen (*Populus grandidentata*). As in the spring, they select only the most protein-rich portions of the new fare, rejecting petioles and twig tips. The crude protein content of all the trees declines through the summer, dropping to less than half of the spring values. This forces the porcupines to absorb more bulk during feeding, yet they continue to gain weight.

Trees have a second, very effective defense against leaf-feeding porcupines. They carry a horribly unbalanced load of sodium and potassium ions. In the porcupine body, these minerals are found in roughly equal ratios. But the summer vegetation threatens the balance, because it has a potassium–sodium ratio in the range of three hundred to one or higher. The porcupine needs the sodium, but it can't hold onto it because its kidneys cannot get rid of the flood of potassium without giving up some sodium as well. The animal must either stop eating green vegetation or find a sodium supplement.

All strict herbivores face this problem, but in the Catskill Mountains, natural supplies of sodium are scarce, and human salt artifacts have a near-fatal hold on porcupines. I have found porcupines traveling almost a mile from deep woods to a farm building, where they spent much of the night chewing on wood laced with sodium chloride. Others traveled to roadsides, looking for traces of salt put down by road crews the previous winter.

During the summers of 1983 and 1984, 59 percent of my study animals were driven out of the forest and to human settlements by their need for sodium. If only adults are considered, the figure jumps to 71 percent. Since the sodium-seeking behavior coincides with the period when porcupines are feeding on greens, I consider it a toll exacted by plants from their herbivore predators.

This toll falls most heavily on lactating females. Infants were never observed chewing salt. Chewing on a building or licking a roadside are unquestionably the two most life-threatening situations a porcupine can find itself in. This suggests that whether a porcupine is killed directly by an angry homeowner or randomly by a

A porcupine absorbs itself in an apple. Porcupines in the Catskill Mountains of New York are partial to apples, especially bland, mealy ones with a low level of organic acid. Trees with higher acid levels could be warding off herbivores.

Leonard Lee Rue III; Bruce Coleman Inc.

speeding car, the probable result is an orphan left in the woods.

The interesting thing about the summer food eaten by the porcupines is that it is extremely rare in my forest study area. Only nine trees out of a thousand are lindens, one out of a thousand is a quaking aspen, and fewer than one out of a thousand a bigtooth aspen. Yet the porcupines travel unerringly in the night to climb a tree of the correct species and feed on it.

The aspens are pioneer species. But once a forest matures, their seedlings can't compete with the climax vegetation of beech, maple, ash, and oak, and the aspen is eliminated. This can't explain the scarcity of the linden, however. I believe this tree may be a fugitive species, which hides from herbivores by keeping scattered. To keep in touch with each other genetically, the lindens produce fragrant flowers that attract bees, thus insuring cross-pollination at a distance.

The loyalty of porcupines to these rare trees intrigued me, but I never suspected how far the animals had taken this loyalty until I began radio tagging them. As I followed my radio-tagged animals, I routinely marked their feeding trees. Frequently, after struggling at night along treacherous terrain, I would locate a porcupine in a linden or an aspen. As I walked around the tree, I would often find my own tiny plastic marker nailed to the bark. Often the animal had been there weeks or months before. In other words, porcupines were recognizing not only a rare desired species; they were picking out specific trees out of hundreds of thousands in their home range. But why?

During the summer of 1984, I selected thirteen linden trees widely spaced in the forest and examined each tree once a week for signs of feeding. Here, the nip twigging behavior of the porcupine became a valuable experimental aid. Even a single petiole-spurred twig can be found by searching under a feeding tree. By comparison, one would have to be tremendously lucky to find the single bite taken out of an accessible tree by a deer.

The results were startling. At the end of the summer, two trees out of the thirteen under surveillance had accounted for 90 percent of all porcupine feeding. Often, after a week's absence, I would carry away armfuls of nip twigs to clear the ground for future observations. The two trees had no more leaf protein than the others. But there was something clearly different about them—their leaves contained only a third as much organic acid as the rejected trees.

I was led to this discovery partially because I had noticed my porcupines avoiding acid in two other circumstances. In addition to tree foliage, a major summer food of the Catskills porcupines is apples. Apple trees do not grow in the mature forest; porcupines travel to the old fields and abandoned orchards on the periphery. The porcupines invested much effort in harvesting apples. One mother traveled almost a mile every night from a resting spot on top of a ridge to an orchard at the bottom, then returned before morning.

Up in the trees, the animals cut nip twigs to harvest fruit growing far out on the branches. They ate only the fruit, which was often harvested while still green. And, as with linden feeding, the animals showed strong preferences for some trees. Some apple trees were stripped bare while neighboring trees lay untouched.

One twisted, hollow-trunked tree I know of stands out as a porcupine favorite. The tree grows on the edge of our orchard and produces early maturing, delicate apples. We seldom get to taste the fruit because porcupines come every summer and strip the tree before the seeds have turned brown. Porcupines tend to be solitary animals, foraging and traveling alone. But on one August night in 1983, I found three animals feeding in the same tree, a record that has not been surpassed. Two of the feeders were males, so upset by each other's company that they spent much of the time grunting at one another instead of feeding. The female, more sensibly, was busy harvesting apples.

The apples of four trees chosen by porcupines did not have any more sugar or crude protein content than the apples of rejected trees. But they did differ significantly in acid levels. The rejected apples contained eleven times more organic acid than those eaten. To me, the apples preferred by porcupines had a bland and mealy taste.

A third acid-avoidance behavior in porcupines cropped up while I was studying salt drive in the animal. To determine what specific salts the animals seek, I built a low cabin and situated it on a porcupine trail. Under the shelter of broad eaves, I attached 180 pickets of wood impregnated with a variety of salt solutions and

Lynn Rogers

The Siberian husky below made the mistake of charging the back of a porcupine and got a faceful of quills. The dog shows no sign of infection; porcupine quills contain an antibiotic that inhibits bacterial growth. At right, a female porcupine in Minnesota serves herself a sapling.

D. Cavagnaro; DRK Photo

arranged randomly. Like Hansel and Gretel's candy house in the woods, my salt house signaled to the passerby: Come and chew. Within a week of putting up the cabin, quilled visitors began arriving.

I confirmed that the animals were seeking sodium. But most interestingly, they showed clear preferences among the nonmetal components of the salts. They preferred sodium acetate, borate, bicarbonate, and other sodium salts of weak acids and made less use of sodium chloride, nitrate, and sulfate, all salts of strong acids. In effect, the animals were seeking the most alkaline sodium salts available.

Thus in leaf feeding, apple feeding, and salt seeking, a common behavioral thread was emerging. Porcupines were trying to minimize their acid intake. The presence of the same behavior in such different contexts suggests an underlying physiological imperative. Why should porcupines avoid dietary acid?

The answer must remain speculative at this time. Perhaps the most obvious place to look is the animal's kidney function. Both acid–base regulation and the regulation of sodium–potassium levels are the tasks of the mammalian kidney. As mentioned before, the porcupine's summer diet floods its system with potassium. Work with other animals shows that an acute increase in acid levels in the blood inhibits the kidney's ability to excrete potassium. And if potassium levels are allowed to rise in the blood, there follows an immediate and severe disruption of muscle and nerve functions.

Are trees defending themselves against porcupines by driving up their acid levels? If so, it's a mechanism that has not been described before. It will be interesting to see whether other leaf-feeding herbivores show the same behavior.

Besides tree leaves and fruit, the porcupines have one more important, but unreliable, food source in late summer and fall—the mast crops, which include acorns of red oak and nuts of the beech tree. Acorns and beechnuts have a much higher caloric content than apples, and porcupines feeding on them put on weight rapidly.

The large oak trees offer comfortable sleeping perches, and a porcupine may stay in the same tree for days at this time, feeding by night and sleeping by day. In October 1984, I was trying hard to capture a female whose radio collar battery was nearing the end of its life expectancy. I reached the animal at midnight on a warm, misty night. The animal was in a giant red oak, hidden among persisting leaves. I could hear her movements above me, punctuated by sounds of acorns falling. I lay down on the ground and waited for her to descend.

I dozed off in the warm night and was awakened about 4:00 A.M. by something pounding the ground near me. I sat up, befuddled, and heard a great snort. A large doe had approached, searching for acorns, and had asked me to declare myself. She now rushed back and forth in great confusion, trembling the ground and looking back in my light beam. Only the porcupine above us retained her composure.

Realizing my quarry would not descend, I trudged home for a proper sleep. When I returned at noon the following day, I found the porcupine sleeping just where I had left her, about forty feet up on a large branch. Below her lay nip twigs and loose acorns from the night's feeding.

Mast crops appear irregularly, in a pattern that no herbivore can depend upon. In my study area, for example, both the beechnut and acorn crops failed in 1983. A few scattered acorns were produced; these were stripped clean by mid-September, well before normal acorn drop in October. As a result, porcupines fell back on the apple crop and also fed heavily on linden and aspens.

Conditions were entirely different in 1984. The trees were full of acorns and beechnuts. The porcupines abandoned the apples and concentrated almost exclusively on mast, with leaves as a garnish. The animals were in excellent physical condition by the time winter returned, but it's impossible to predict what will happen this year. That unpredictability, I believe, is another way the trees resist their herbivore predators.

Even if the mast crop fails, my porcupines will adapt. The forest may have an impressive arsenal of weapons and tactics for protecting its resources from these quiet, tenacious predators, but the porcupines have structural and behavioral tools for survival. To my mind, it's an even match. In my years as a follower of porcupines, I have come to regard these animals as superb foresters. They have much to teach, not only about themselves, but about the forest that has sustained them through two million cycles of spring, summer, fall, and winter. □

Inconspicuous among the shrubs of South Africa's Cape region, the cupped, gray-green leaves of a protea plant hide scores of blossoms from birds and flying insects.

Delbert Wiens

Secrets of a Cryptic Flower

The way to a pollinator's heart is sometimes through its sweet tooth

by Delbert Wiens

The Cape region of South Africa is well known in biological circles for the great diversity and beauty of its indigenous flora. But of all the Cape's intriguing plants, proteas reign supreme. These remarkable plants are shrubs or small trees whose flowers—usually borne in large, conspicuous yellow or red heads—are typically pollinated by the protea bird (*Promerops cafer,* also known as the Cape sugar bird). The plant genus *Protea* was named for Proteus, the Greek god who could assume many different forms, and its various species also take some surprising forms. Some are singularly unprepossessing. Their flowering heads are comparatively small, not especially showy, and sometimes even cryptic—that is, hidden deep within the foliage. We now know that these proteas are pollinated, not by birds, but by small terrestrial mammals, mostly rodents.

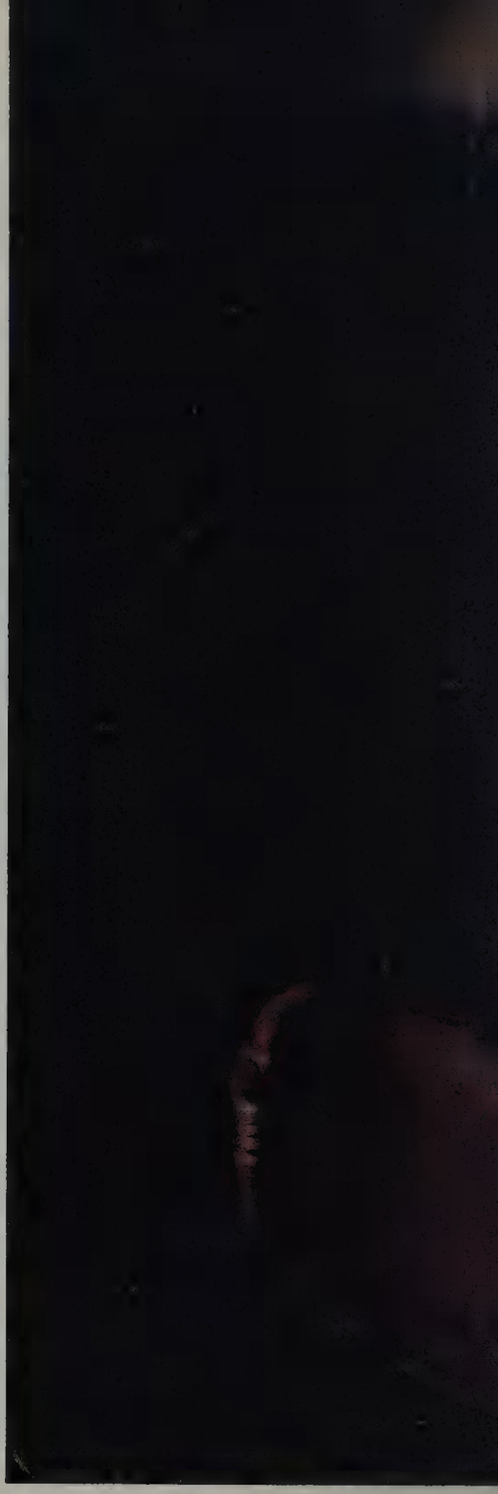
My experience with these plants and their pollinators began in 1972, in Cape Town, South Africa, while I was visiting John Rourke, longtime student of Proteaceae. One evening after dinner, John and I thumbed through one of the many popular books on this plant family. When we came to the photographs of several proteas with cryptic flower heads, he asked me what I thought could possibly pollinate such flowers. I hesitated, for the idea seemed so strange, but finally suggested small mammals. He replied that this was also his guess, as well as that of Knut Faegri, a well-known Norwegian pollination biologist.

Intrigued by this possibility, a few days later we examined several species in the field. A few of the succulent bracts surrounding the heads showed evidence of having been chewed, rodent runways connected individual proteas, and there were even burrows at the base of some plants. The heads secreted copious sweet nectar and produced a yeastlike odor. While these observations supported the possibility of small-mammal pollination, the idea still seemed bizarre. With the exception of bats, I knew of no other mammalian pollinators. Although the Austrian naturalist O. Porsch, looking at Australian plants, suggested the possibility in the 1930s, and

Delbert Wiens

Drawn by sugary nectar, several types of terrestrial mammals visit cryptic proteas. Below, a Namaqua rock mouse visits a ground-flowering protea. Right: Protea flower heads are complex, composed of hundreds of small florets. In this species, the flower head opens slowly from the perimeter, gradually exposing pollen-laden styles to potential pollinators.

J.A.L. Cooke; Oxford Scientific Films



M.K. Morcombe had observed a case of probable rodent pollination in Australia in the 1960s, no quantitative data were available, and certainly no one had given much credence to the idea. We needed unequivocal experimental verification to convince ourselves, let alone others.

Unfortunately, I was on the eve of departure for Australia, and John Rourke was preoccupied with other matters, so the idea was necessarily put aside. He mentioned, however, that he believed there were Australian proteas that strongly resembled those of southern Africa. Several weeks later, in southwestern Australia, I did indeed discover several proteas with floral structures, habits, nectar quantities, and odors strikingly similar to those of the proteas I had observed in southern Africa. Furthermore, the environment of southwestern Australia—with its shrubby, Mediterranean-like vegetation, climate, and soils—strongly resembled that of the Cape region. Could ecological factors in these two distant regions of the earth have somehow promoted pollination by small terrestrial mammals? Again, the situation did not allow detailed studies, but the question was now more intriguing than ever.

Time and circumstance did not permit further investigation of the problem for five years. In the interim Rourke had discovered a study site, approximately sixty miles northeast of Cape Town, on Jonaskop (Jonas head), a mountain in one of the outlying Cape ranges called Riviersonderendberge ("mountains of the river without end," a typically descriptive name so common to the Afrikaans language). Jonaskop reaches an elevation of about

,000 feet (high for the Cape region), but nost importantly, its vegetation was rela-ively undisturbed, access was limited, nd there were well-developed stands of at east nine species of proteas, three of vhich we believed might be pollinated by errestrial mammals.

On Jonaskop I put out a series of live raps in dense stands of *Protea am-plexicaulis* and *P. humiflora*, two species ve believed might be pollinated by small nammals. For several days, I caught a number of such animals, mostly nocturnal odents. One evening, I put a fresh, nectar-ous head of *P. humiflora* into a cage with Namaqua rock mouse. The result was in-tantaneous and dramatic.

The mouse emerged from its sleeping ube (a small, cylindrical cardboard con-ainer), raised its snout in an obvious melling gesture, and then proceeded di-rectly to the protea head (which I had placed out of sight behind the tube). For the next fifteen minutes, the animal inter-mittently lapped nectar from the head; its snout became covered with pollen. Fur-thermore, the structure of the flowering head dictated the animal's feeding behav-ior. Because the styles of the one hundred or more individual flowers that make up a protea head always curve inward, animals attempting to lap nectar must forage from the center of the head outward. The nec-tar reservoirs are located beneath the in-wardly curving style; animals attempting to forage from the outside of a flower head go through all manner of futile contortions to obtain nectar and in a short time repo-sition themselves in the "proper" way. Pol-len is dispersed from a special region on the style known as the pollen presenter, and while foraging, animals both accumu-late large amounts of pollen on their snouts and make contact with the stig-matic surface. Even the most skeptical ob-server could hardly fail to be convinced that these animals effected pollination. The same result was obtained with *P. am-plexicaulis* and another Namaqua rock mouse.

Following these observations, we made detailed investigations in the field during the next three years. One perplexing tech-nical problem, which overshadowed all as-pects of the study, involved gathering data about an event that was difficult to ob-serve in nature because the flowering heads were cryptic and the pollinators nocturnal. We approached the problem in several ways. First, we demarcated several permanent study sites on Jonaskop in well-developed stands of *P. amplexicaulis* and *P. humiflora*; then, to obtain information

about the small mammals, we established a grid of one hundred live traps in dense stands of these plants. We were thus able to determine the species composition, density, activity periods, and movement patterns of the small-mammal community (at least those that were readily caught in live traps). The most prevalent small mammals associated with the two flowers under study were the Namaqua rock mouse, the Cape striped field mouse, and the spiny mouse. Animals caught in smaller numbers were elephant shrews, Verreaux's mouse, the dormouse, an African climbing mouse, and a small African species of house mouse.

Although these animals typically wet-groom their snouts after foraging, some pollen always remains to be transferred to the next flower. Because of its stickiness, the pollen cannot be dispersed by wind, and any grains found on animals' snouts can only be explained as the result of foraging for nectar in protea flowers. Virtually all of the approximately 150 small mammals we sampled had protea pollen on their snouts, although the quantities varied greatly. Since these animals presumably ingest pollen during wet-grooming, we reasoned that pollen should also accumulate in the feces—a prediction that proved correct.

To study foraging behavior, we observed and filmed captive individuals of three of the five types of small mammals mentioned above. Finally, to determine whether these animals preferred the protea species that we hypothesized were pollinated by terrestrial mammals, we conducted simple T-maze experiments. Conspicuous protea heads, which were typically pollinated by birds, were presented to the rodents along with samples of the cryptic species. In virtually every case, the animals foraged on the cryptic flower heads. In another experiment, we marked protea flower heads with powders that fluoresced under ultraviolet light; later the same night, we trapped animals bearing large quantities of the powder, usually on the snout and feet. With these strategies we obtained a considerable amount of pertinent information without ever seeing animals foraging on the flowers in nature (animals were both observed and captured on the plants, however, and many were trapped at the bases).

These observations do not mean that only small terrestrial rodents visit and pollinate protea plants with cryptic flower heads. A single species of pollinator, or even a group of related pollinating animals, is rarely solely responsible for pollen transfer in any plant species. Instead, there is typically a group of major pollinators for which the flowers are primarily adapted in terms of attraction and reward. There are usually secondary and tertiary pollinators as well, but these are not efficient pollinators.

Virtually all evidence supports the view that rodents are the primary pollinators of proteas; yet we know that many insects, especially bees and beetles, visit the flowering heads. For example, during the occasional warm days in early spring, African honeybees visit any protea flowering head in profusion. By enclosing newly opened flowering heads in wire cages that prevented visits from rodents but permitted relatively free access to bees and other insects, we were able to measure the pollination efficiency of the secondary and tertiary visitors. In one protea species, the exclusion of mammals reduced seed set by about 50 percent. In another, it was reduced approximately twentyfold, and a number of the caged heads set no seeds whatsoever. The individual florets of the flowering head are constructed so that insects can only effect pollination in the event that while collecting pollen from the pollen presenter they accidentally contact the stigma. Any insect that forages solely for nectar will not contact the stigma and pollination cannot occur.

L. Cooke; Animals Animals/OSF

ectar is held at the base of each floret in the protea flower
ad (cross section, below). While bees and beetles can gather
ctar without touching the pollen on the brownish red anthers,
ammals (such as the Namaqua rock mouse at left) cannot
sily avoid picking up and transferring the sticky pollen
ains, thereby fertilizing the plant.

L. Cooke; Earth Scenes/OSF

Both the shrubby vegetation of the ape and the area in which it grows are own locally as *fynbos* (literally, delicate rub). Despite being restricted to a nar- w coastal belt extending 50 to 75 miles rth and about 250 miles east of the ape, the *fynbos* has a distinctive enough mbination of climate, geography, and ant and animal species to be considered unique ecosystem. In its general aspect, e ecosystem is not unlike those of south- n California, central Chile, southeastern ustralia, and the lands surrounding the lediterranean itself. The *fynbos* has any characteristic features. For in- ance, there are almost no native trees or nuals, and many of the plants have ad- tations to survive periodic burning. But rhaps the most astonishing feature is e area's richness of flowering plant spe- es. Although it is restricted to the Table lountain sandstone, a soil notoriously de- cient in minerals, the *fynbos* supports a rodigious 8,850 species of flowering ants; 73 percent of these occur nowhere se on earth. The uplift and subsequent rosion of this sandstone formation have roduced many small mountain ranges ith diverse elevations, precipitation, and ils. The great diversity of species was no ubt influenced by this variety of habi- ts. The extent of the species richness is perhaps difficult to appreciate, but consider that the Cape peninsula averages about 5.7 miles in width and is approximately 20 miles long, yet it contains 2,250 species of flowering plants. By comparison, the entire Great Plains of the United States and southern Canada (about 800 by 1,200 miles) has only about 3,000 flowering plant species.

The *fynbos* on Jonaskop is largely undisturbed. The treeless slopes are densely covered with brownish green, thick-leaved shrubs representing an impressive array of species. Troops of the chacma baboon also live on Jonaskop and seem to play an unusual predatory role with respect to the rodent-pollinated proteas. They apparently tear the flowering heads from the bushes in order to suck the nectar; thousands of such heads often lie in piles of about five to fifteen in stands of *P. humiflora*. Other animals on Jonaskop include the klipspringer, reedbuck, and probably the leopard, but they are secretive and rarely seen. Local names of plants, such as *renosterbos* (rhinoceros bush), suggest the diversity of large mammals that inhabited the region prior to white settlement; today these animals are restricted to national parks.

Southern Africa has a rich bird fauna, and in extensive stands of bird-pollinated proteas of the Cape region, one can always see the protea bird. The protea bird's entire life history is inextricably linked to proteas. The bird obtains food (nectar) from the plant, usually nests in it, and also uses the brown, fluffy seed hairs to line its nest. The bird's breeding season also coincides with the flowering of certain proteas, and the young are partly fed on the nectar. On still nights one can occasionally hear eagle owls, one of perhaps a dozen raptors hunting in the African night skies. Night-flying raptors are a threat to the small mammals that pollinate the proteas, and it may be that the presence of such predators was an indirect influence on the evolution of cryptic protea species. Since a flower well hidden under foliage best protects its mammal pollinators, it also has the best chance of being pollinated and reproducing. These conditions, therefore, represent the geographical and biological settings in which rodent pollination evolved. What are some of its more interesting features?

One aspect of the system involves the pattern of adaptation between the flowers and the small mammals. These adaptations are all one way; the proteas have evolved to attract and reward small-mammal visits to the flowers without reciprocal adaptations by the small mammals for either enhancing foraging efficiency or effectively using nectar as a food. This lack of reciprocity contrasts sharply with most pollination systems, in which there are striking structural, behavioral, and physiological adaptations by both pollinator and flower. (Picture the hummingbird's long bill and a long, tubular flower.) Several observations bear on the questions of why such a system evolved, and why in the Cape region, but the answers must necessarily remain speculative.

Most of the mammal-pollinated protea species are found in small, restricted populations. Often they are associated with the specific soil types of relatively high elevations in the outlying Cape mountain ranges. In contrast, many bird-pollinated proteas grow in dense stands covering many acres; apparently, such a population structure is necessary to attract large numbers of the migrating flower birds associated with these proteas.

Many proteas, like this Leucosperma glabrum, *are pollinated not by nocturnal mammals but by birds during the day. Because they are exposed, upright, and colorful, the flower heads are easily seen by flying visitors.*

J.A.L. Cooke; Earth Scenes/OSF

The proteas adapted for pollination by nonflying mammals probably evolved from bird-pollinated prototypes and retain many of their features, such as large flowers, sturdy inflorescences, and copious quantities of nectar. The gradual development of small protea populations with highly specialized soil requirements probably resulted from the erosion that partitioned the Table Mountain sandstone.

This continuing restriction of population size may have ultimately provided earthbound mammals with several advantages over birds as pollinators. These small mammals are ubiquitous, nonhibernating, nonmigratory, and generalist feeders; thus they might be more readily attracted to an ephemeral and highly localized food resource than more specialized feeders such as birds. They might also offer more reliable pollination service than insects, such as honeybees and beetles, which are necessarily restricted in their activities by the long periods of low temperature and high precipitation typical of late winter and early spring in the Cape region, when these proteas flower.

Thus the high frequency of small, localized populations of proteas (and numerous other species in the *fynbos*, many of which face imminent extinction) may account for the independent evolution of pollination by nonflying mammals here and in southwestern Australia, where similar population structures occur. Whether this hypothesis can explain the apparent rarity of nonflying mammals as pollinators in the rest of the world remains to be tested.

The small, geographically restricted populations may also explain why there are no reciprocal adaptations by the pollinators. Typically, so few small mammals occur in a population of these proteas that any genetic recombination or mutation favoring better use of the resource would be swamped out by interbreeding with adjacent populations in areas without proteas. Furthermore, the resource is time limited—available only about four to six weeks of the year. For coevolution to occur among long-lived, continually active organisms, the resource must be available throughout the year. In the case of ephemeral insects such as solitary bees, coevolution can occur so long as the insects are active when the plants flower.

All pollination systems require two elements: an attraction and a reward (or promise thereof). The proteas' attraction is olfactory; they produce either a yeasty odor or a more pungent one reminiscent of rancid butter. Each basic odor has slight variations, depending on the species. The reward is nectar.

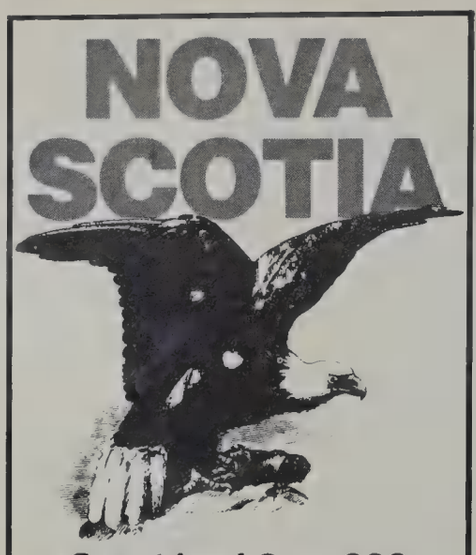
The nectar has several distinctive features: It is secreted in relatively large quantities (by the milliliter) and has a high sugar content (roughly 40 percent), of which about 50 percent is sucrose (table sugar), giving the nectar a particularly sweet taste. The relatively large quantities of nectar produced effectively attract small mammals, which require proportionately greater energetic rewards. Initial estimates, however, suggest that the total nectar production of a protea population can supply the energy requirements of the small mammals on our study sites for only about eight days of the year. Thus the nectar cannot be an important part of the animals' diet. Other populations of the same species of small mammals, living only a short distance from the proteas, are primarily seed eaters that never have access to nectar, yet they survive without difficulty. Why then should the small mammals bother to visit the flowers and forage for nectar at all?

The answer may rest with the remarkably sweet and tasty nectar. Rodents, and many other mammals, have a "sweet tooth." Consider for a moment the millions of acres of agricultural land devoted to sucrose production for human consumption, not to mention the worldwide honey industry. These products are not only unnecessary to the human diet but are often deleterious. Yet sugar craving provides the basis for the entire "junk food" industry, from soft drinks and breakfast cereals to confections. Proteas appear to have employed the junk food principle to attract small mammals to their flowers. In other words, the sweetness of protea nectar is so enticing to small mammals that the flowers do not have to supply much of it in terms of the animals' overall energetic needs.

Though it is still too early to know just how common pollination by nonflying mammals is, the phenomenon is obviously rare compared with pollination by such animals as bees, moths, and bats. We do not know why so few land animals became pollinators. It may simply be that flying animals—such as bats, bees, and moths move pollen more efficiently. Throughout evolutionary history, plants have acquired traits that attract and reward the more efficient pollinators. Robert Sussman and Peter Raven have argued that pollination by nonflying mammals was more common before the evolution of the flying mammals (bats), which outcompeted the less mobile terrestrial and climbing species, particularly in the tropics. They suggest that this is why most pollination systems that depend on nonflying mammals for pollen transfer are today restricted primarily to regions where flower-feeding bats are absent.

What might be the consequences if large numbers of plants depended on pollination by nonflying mammals? First, the nature of the reward should change from the junk food variety to a nutritionally valuable resource, since animals would have to use it as a major dietary component. Consequently, the plant–animal interaction should then shift toward a coevolved system, as in the case of proteas and protea birds. This is probably the situation in parts of Australia where several mouselike marsupials, such as the honey opossum, have become adapted for diets of nectar and pollen. Yet even here, species adapted for pollination by nonflying mammals probably do not form a major component of the plant community.

For the past several decades, pollination systems have been extensively studied to elucidate a broad spectrum of ecological and evolutionary questions, such as mutualistic and coevolutionary phenomena, optimal foraging, gene flow, and energetic relationships. Thus, in addition to its intrinsic interest, the discovery of a wholly new system of pollination provides a new model for experimental analyses and also tests whether current theory for the origin and function of pollination systems is adequate. □



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A Library of Bones

If all the bones in the American Museum of Natural History were dumped in Central Park, they would form a pile well over three stories high and 200 feet in circumference. A very rough calculation indicates the pile would weigh about 1,000 tons and contain about 50 million bones, representing the remains of more than 750,000 animals.

The Museum's bones come from every corner of the globe—from Outer Mongolia to East 59th Street. The people who found them endured blizzards, sandstorms, fights with bandits, and a host of hardships to get them. Some collectors even risked their lives or spent their personal fortunes in the effort. Almost all the bones—more than 99 percent—were collected for scientific purposes and are not on public display. More than two hundred scientists and their assistants conduct research in the Museum, and much of it focuses on bones.

One such scientist is curator Malcolm McKenna, a paleontologist who specializes in fossils of early mammals. There is no mistaking the subject of his research—boxes of fossil bones, all carefully labeled and numbered, cover most of the tables in his spacious office. McKenna explains that much of his work deals with bones he himself has gathered in the field. During his thirty or so years in paleontology, he has prospected on just about every continent, looking for extremely rare fossils of early mammals in regions as distant as Patagonia and Greenland.

McKenna brought out a plastic box filled with his recent finds, which looked like tiny chips of stone but turned out to be hundreds of minuscule fossil teeth, tiny jaws a quarter-inch in length, together with other irregular bits and pieces of fossil bone. In all, the box held less than two ounces of fossils. They dated, McKenna said, from about sixty-six million years ago and were discovered in Cretaceous beds at Lance Creek, Wyoming.

The fossils are rare. "To get this little box of jaws and teeth," he said, "a field crew of eight people had to process five tons of matrix [fossil-bearing rock] every day for a week." McKenna spends most of his summers in the field collecting fossils such as these. Over the years, he has developed a collecting method that differs radically from earlier methods. He collects entire fossil communities—fossil ecologies—rather than individual specimens; to do this, McKenna has to extract almost every fossil larger than a small pebble from a particular deposit.

"I want to get the best representation of life for that particular moment of time," he explained. "My research requires the highest-resolution data—the most detailed and complete picture possible." To accomplish this, McKenna and his field crew dig up the matrix, which at Lance Creek is made up of ancient channel sands crossbedded with layers of clay. (The highest concentrations of the fossils McKenna is after can be found in these "fossil garbage dumps" in ancient stream beds, where flash floods and other processes have deposited a great assortment of bones, many of them contained in carnivore scat.) First, the matrix is put in water, then it is sifted through a fine wire-mesh screen. The screen catches thousands of pebbles—and, if McKenna and his crew are lucky, a fossil tooth or two. In one day, working in assembly-line fashion, the crew can process 550 boxes of matrix, each weighing twenty pounds, for a total of about five tons. "It's very tedious work," McKenna said. "You have to go through a lot of beer and Cutty Sark just to find one

ssil." (Indeed, one of McKenna's col-
agues named a new species *Cuttysarkus*
cnallyi because the discoverer had been
omised a bottle of the scotch if he found
mammal jaw with six or more teeth in
)

McKenna's collecting method is effi-
ent. "The first day we spent at Lance
reek in 1956," McKenna said, "we col-
cted more fossils than everyone else
ce the fossil locality was discovered."
t the fossils are so rare that an entire
mmer's work could fit in a small piece of
rry-on luggage for the return flight to
ew York.

McKenna poked his finger around the
x of fossils. "This box represents," he
id, "a picture of the animal life of that
rticular area at a particular moment in
ne—in this case, about sixty-six million
ars ago, around the time of the mass ex-
ction at the end of the Cretaceous."
ance Creek has fossils of about eighty
nds of animals, including fishes, lizards,
y and large dinosaurs, frogs, salaman-
rs, birds, and early mammals. "I keep
e mammal bones," he said, "and spin off
e rest of the fossils to other scientists."

"What can these bones tell us? An ex-
aordinary amount, it turns out. There
e many levels of 'boniness.' Bones have
exterior shape, which tells us about the
atomy of the animal and what it did for
living. Bones have an interior structure,
hich can provide clues about whether
e animal was warmblooded. Some bones
ve growth rings, which indicate whether
e animal lived in a variable climate and
d to slow down for a period every year.
ones also have a microscopic structure,
hich can show such things as the metab-
ism of the animal."

Since teeth survive better than other
ones, they make up most of the contents of McKenna's box. Mammal teeth are almost a fingerprint of the animal—they are highly complicated structures with ridges, valleys, spikes, ribs, ripples, pits, and points. Few species have teeth that look exactly the same as those of another species. Consequently, a paleontologist can sometimes identify an animal fairly closely by looking at a single tooth and can usually identify it with certainty from a jaw with two or three teeth. Equally helpful, mammalian teeth don't get any bigger as the animal grows in size. Teeth remain constant for a given species, except for wear.

Once McKenna has identified the animals living in a specific community, he moves on to some of the larger questions. Bones can reveal something about the behavior of the animal, for example. "Take foot bones," he said. "What was the animal doing with its feet? Was it hopping, swimming, galloping, climbing in trees?" Since bones have marks where ligaments and muscles were attached, the paleontologist can actually determine an extinct animal's musculature and reconstruct the form of the animal itself.

Once paleontologists know what the animal looked like, they can start reconstructing its habitat. If the animal was a hopper, for example, it may have lived in an arid, sandy area. If the animal climbed trees, its habitat is self-evident, even if no tree fossils are present.

McKenna continued. "Much of this information can be found by studying this little box of fossils. You can actually work out the census structure of the community with these fossils. You can tell a lot about its ecology. How did the animals interact? For example"—he paused to pick out a tooth from the box—"this mammal tooth passed through the alimentary tract of a

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big reptilian meat eater, such as a crocodile. How do I know? The tooth has been etched by stomach acid—see, it looks frosted. I suspect it was a crocodile because crocodiles have very acidic stomachs. So we know what animals were eating what."

But this is just the beginning, according to McKenna. "If you want to answer the largest questions in science—and this is the goal of most scientists—you have to study the highest-resolution data possible. You can spin theories with a bone here and a bone there, but what you really need are many, many bones of many kinds from one locality at one time.

"By looking at fossil assemblages in a number of areas, you can correlate assemblages to within about one percent of their real age. Then, by studying successive layers, a paleontologist can learn how the community and the climate evolved over time. If a group of species suddenly went extinct, the paleontologist can look for the reason. Thus, even a small area can yield information about the earth as a whole."

This can be taken even further. By comparing two sets of layers in different sites, paleontologists can gain data that will help draw a hypothetical map of the earth as it appeared at a point in the distant past. "Let's say you're studying two localities, one in France and one in Wyoming," says McKenna. "In layers about fifty million years old in France and Wyoming, most of the animals are normally quite different. But about sixty million years ago, European and North American deposits began to have many animals in common. What do you conclude? Possibly that some sort of connection—a land bridge—was present between Europe and North America for a while. By looking at other scientific data, you recall that huge lava flows occurred where Greenland was close to Scotland. Europe and North America were much closer together at that time. Thus, you hypothesize that a land bridge developed between sixty million and fifty-five million years ago across the North Atlantic. Five million years later the two faunas—in Wyoming and France—were different again. Therefore, you conclude that the sea encroached upon the land bridge and cut off that particular route of interchange, after which the faunas of the separated areas evolved independently."

The amount of information bones can provide is limited only by the questions we ask. One question McKenna has been working on is whether the dinosaurs died out suddenly or gradually, and he collected the Lance Creek fossils because he knew the strata dated from the end of the Cretaceous, when the dinosaurs becam extinct.

"When did the dinosaurs disappear' McKenna asked. "Was the extinctio caused by a bolide impact? Paleontol gists find that the dinosaurs became e tinct *before* the event that left a layer iridium and other apparently extraterre trial debris around the world. There is small but significant thickness of roc without dinosaur fossils underneath th iridium layer. That they could have bee around but not found is possible, but th chance of that is about 3 percent or eve less. Now this is a fascinating observatio Could the various extinctions *and* th bolide impact have been caused by th same thing? Here's where paleontolog and other scientific disciplines can pr vide important information. If we con bine our data with astronomical data, w can tell something about the history of th earth in relation to the solar system.

"Paleontologists have noted a periodi ity in mass extinctions. Astronomers hav noted a periodicity in the path of the sola system as it passes back and forth throug the galactic plane. Geologists have noted periodicity in the formation of ancient me teorite craters on the earth. Geophysicist have suggested a periodicity in magneti reversals. Could all these things be re

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ıted?" McKenna noted that a number of ıeories relate some of these observations.)ne theory, for example, hypothesizes the xistence of a dark companion star to the un that periodically swings close to our olar system and sends comets plunging ıto earth-crossing orbits, some to strike he earth.

"The point here is that all the various cientific disciplines come together and êst each other's theories. What we are do-ng—in the Museum and elsewhere—is outting together a general picture of the arth. We want to construct the entire his-ory of our planet, not just the history of ınimal life. This is real natural history—ıot just biology. We're not the American Museum of Biology. What we are working on here in the Museum has consequences ınd implications throughout science, from ıstronomy to geophysics.

"The reason we collect bones is to build ıp a library of *facts*. It's not postage stamp collecting by any means. Bones, and in-deed all scientific collections, differ from books in that books are opinion and inter-pretation while specimens are facts. Mu-seums are different from universities. Bones are one of our greatest links with he past—they are our record of extinct vertebrate life on this planet."

Douglas J. Preston

At the American Museum

Adirondack Anniversary

On May 15, 1885, the Adirondacks in upstate New York became a forest preserve. The Membership Office will mark the *Adirondack Centennial* with a special exhibit and program on Tuesday, May 14, in the Hall of Northwest Coast Indians and the Auditorium. Between 6:30 and 7:30 P.M., Museum scientists and visiting specialists on the Adirondacks will set up special displays on the region's wildlife, geology, and ecology. At 7:30 P.M., in the Auditorium, Peter Berle, former commissioner of the Department of Environmental Conservation, will narrate a slide show of striking photographs of the Adirondacks. The program is free for members, $3 for nonmembers. Tickets are required; for information call (212) 873-1327.

Margaret Mead and Film

Margaret Mead strongly advocated the use of film in anthropological fieldwork. Paul Byers, who studied with Mead, will show several of Mead's classic films, as well as examples of footage she used in her teaching, and discuss her use of the medium. *Margaret Mead and Film* will take place on Wednesday, May 15, at 7:00 P.M. in the Auditorium and is free to the public.

Celestial Rhythms

The Planetarium will present an electronic concert of contemporary and classical music by three Planetarium musician-composers. Accompanied by an array of laser and special effects, the musicians will play selections from *Star Wars, The Right Stuff,* and Pachelbel's *Canon in D Major,* among other works. For ticket information call (212) 873-5714.

Matteo

Matteo and his EthnoAmerican Dance Theater will offer a program of dance from around the world on Tuesday, May 21, at 7:30 P.M. in the Auditorium. *Dance: Sounds, Symbols, and Styles* will feature dances from the Middle East, India, southern Spain, and other regions. Tickets are $3 for members, $6 for nonmembers; for more information contact the Membership Office at (212) 873-1327.

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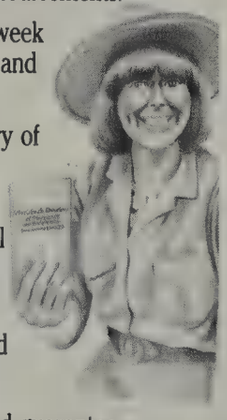

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Bright and Dim Planets

by Thomas D. Nicholson

Venus takes a prominent place in the morning sky this month, having brightened swiftly since inferior conjunction (passing between the earth and the sun) in early April. Although it moves farther west of the sun this month, it remains relatively low in the dawn sky. This is a good opportunity to look for the planet in daylight, however. At about 11 A.M. to noon, it will be roughly 45 degrees west (right) of the sun and at about the same elevation. Venus is bright enough to see without binoculars, but they will help in finding it.

At dawn, while Venus is in the east, Saturn and Jupiter are in the west—Saturn dim and just about setting, Jupiter very bright in the southwest. Saturn moves into the evening sky this month, rising in the southeast at about sundown. Jupiter remains a morning star until early August, rising about four hours ahead of the sun. Mercury is also a morning star, but Mars is an evening star. Both are dim and poorly placed for viewing.

Events in the calendar are given in local time unless indicated otherwise. (Add one hour for daylight saving time.)

May 1: Mercury is at its greatest distance to the sun's right (westerly elongation), but in May that means more southerly as well. Despite the distance, this is not a good elongation. The moon starts out the month in great shape—bright, fat, and gibbous in phase, up until about 4:00 A.M. It is midway between Virgo's brightest star, Spica (left of the moon), and Leo's Regulus (right of the moon).

May 2–3: The moon's position on these nights brackets Spica, moving from right to left of the star on the 3d.

May 4: There is a total lunar eclipse today, but because it occurs over parts of

Celestial Events

sia, Europe, and Africa—before the oon rises in the Americas—we will miss We will, however, get the perigee spring des. Full moon is at 2:53 P.M., EST, and erigee is about fifteen hours earlier. High des will be affected tonight and on the orning of the 5th.

May 5: Test the brightness of tonight's bbous moon by looking for Saturn and ntares (Scorpius's bright star). The oon splits them as they rise in the east af- r dusk—Saturn above the moon, An- res just below.

May 6: The moon rises after and below ntares tonight and is in the "thirteenth onstellation of the zodiac," Ophiuchus, hich occupies a small region between corpius and Sagittarius.

May 9: Venus entered the morning sky nly five weeks ago, yet here it is at great- st brilliancy as a morning star. It rises arly but remains low in the dawn sky, al- hough its brightness will make it visible if he eastern sky is clear.

May 10: The moon is in the morning ky, near Jupiter in Capricornus.

May 11: Last-quarter moon, at 12:34 M., EST, is entering Aquarius. Mars, ill trailing the sun in the evening, drifts owly east, past Antares, in Taurus.

May 15: When it reaches the point in he sky opposite the sun, Saturn becomes n evening star, rising with sunset and set- ng at sunrise. It is still up at dawn, in the est. The bright object near the moon at awn is Venus.

May 16: This is probably the last morn- ng to see the late crescent moon before it noves between the earth and the sun. Apogee moon (farthest from the earth) oc- urs later in the day.

May 19: New moon, in Taurus, is at :41 P.M., EST. A partial eclipse of the

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sun, visible from parts of Asia, Alaska, Canada, and Greenland, occurs today.

May 21: Mars is just below the early two-day-old crescent moon this evening. They are both in Taurus, to the left of Aldebaran.

May 22–23: The widening crescent moon is passing through Gemini. The stars above the moon on the 23d are Pollux and Castor.

May 26: Regulus, in Leo, is just below the waxing crescent moon, which is almost at first-quarter.

May 27: First-quarter moon is at 7:56 A.M., EST. Tonight it is in Leo, with Regulus and the curved Lion's head to its right, and Denebola (at Leo's tail) above and to its left.

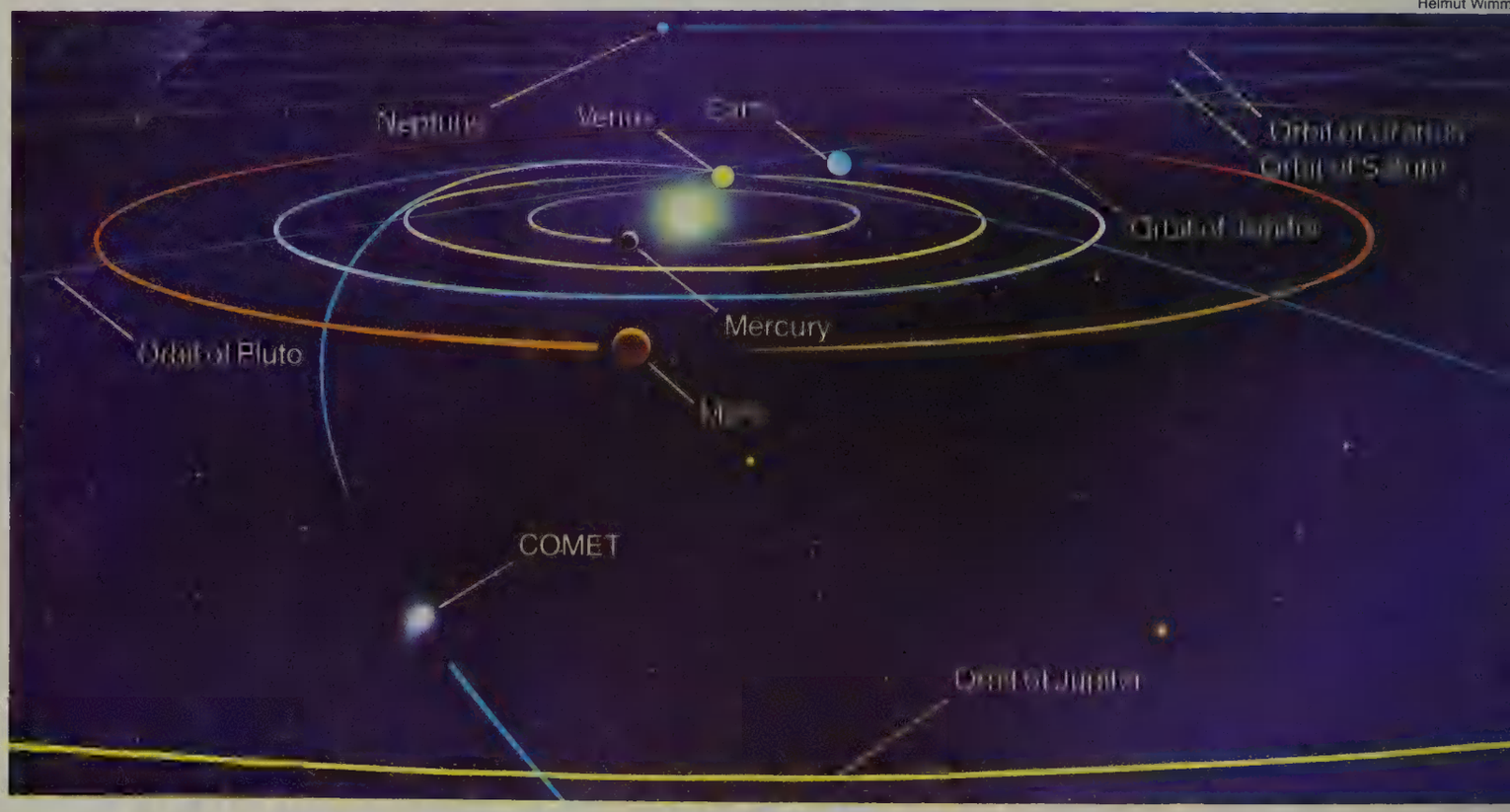
May 30: The star below the moon is Spica, in Virgo. This is the second time in May the moon has passed Spica. Note that the last time it passed the star (twenty-seven and one-half days ago, the 3d), the lunar phase was much late

May 31: The moon, waxing through i gibbous stage and three days short of b coming full, ends the month in Libra, mi way between Spica (to its right), and A tares (to its left).

Editor's Note: The Sky Map in the Apr issue shows the constellations and stars f this month and gives the times for use.

Halley's Comeback

Helmut Wimm



Halley's comet is still in the evening sky in May, above the western horizon at sundown but setting an hour and a half later. A small, dim, starlike object near the Hyades (the "face" of the Bull), Halley is still many months away from looking like a prominent comet.

Popularly, comets "race aross the sky," but actually, they are among the "tortoises" of the solar system. This month's illustration shows Halley's comet between the orbits of Jupiter and Mars (though well south of their orbital planes). But if you compare the May illustration with April's, you will see how little the comet has advanced in its goal of circling the sun. Despite its orbital speed (now some 41,000 miles per hour with respect to the sun) and its motion since mid-April (about 369 million miles, bringing it some 29 million miles closer to the sun), the comet has advanced only one-tenth of the way between the orbits of Jupiter and Mars.

Halley's comet is racing faster and faster toward the sun. On the first day of the year, its orbital velocity was about 35,000 miles per hour; by the end of November, it will almost double that, closing its distance to the sun at a proportionally accelerating rate. The comet is already 122 million miles closer to the sun than it was at the beginning of the year. Not so with its distance from the earth, however. At mid-May, Halley's comet is more than 50 million miles farther away from the earth than it was on January 1. The reason is the earth's orbital motion, which takes us alternately closer and farther from the comet's orbit.

Since the beginning of the year, Halley's comet has been an evening star. The earth was closest to it—about 400 millio miles away—on January 13, when it passed between the come and the sun. The earth moves gradually away from the come until May 2, when the distance between them is 455 millio miles. During May, the earth and Halley's comet move closer by the end of the month, they are about 444 million miles apar (and closing). Shortly thereafter, on June 12, the earth's motio takes the comet from the sun's left to its right, into the morning sky, where it will be until late November.

When will we see Halley's comet? Perhaps not until Novem ber. This month, however, we can see a meteor shower associ ated with Halley's comet—the Eta Aquarid—if the weather co operates. The shower is at maximum early on the morning o May 4. If you get up at about 1:00 A.M. and watch patiently, you may see a meteor streaking across the sky. Unfortunately, the moon will be up in the southwest, nearly full. But the Eta Aquarids are known as swift, often bright objects, and the brightest ones may be seen easily through the scattered moon light. If you do see one (perhaps even on the morning of the 3d or 5th, when there may still be twenty meteors per hour), you may be looking at a piece of Halley's comet, blown off the comet long ago and following the same orbit around the sun. It will finally enter the earth's atmosphere to become a meteor. Don't worry if you miss the meteors this year. There will be more next year, and every year in May, if this faithful shower holds up. (Still another meteor shower is linked with Halley's comet—the Orionid—seen each year in late October.)

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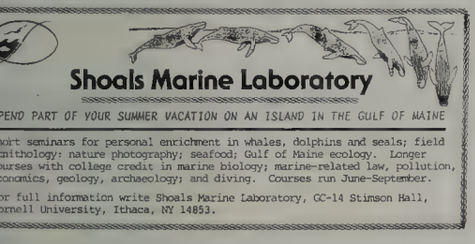
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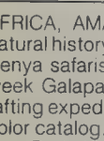

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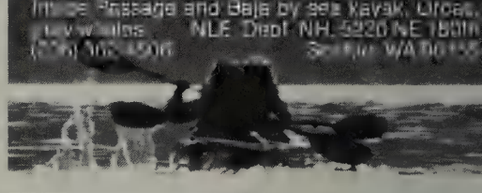

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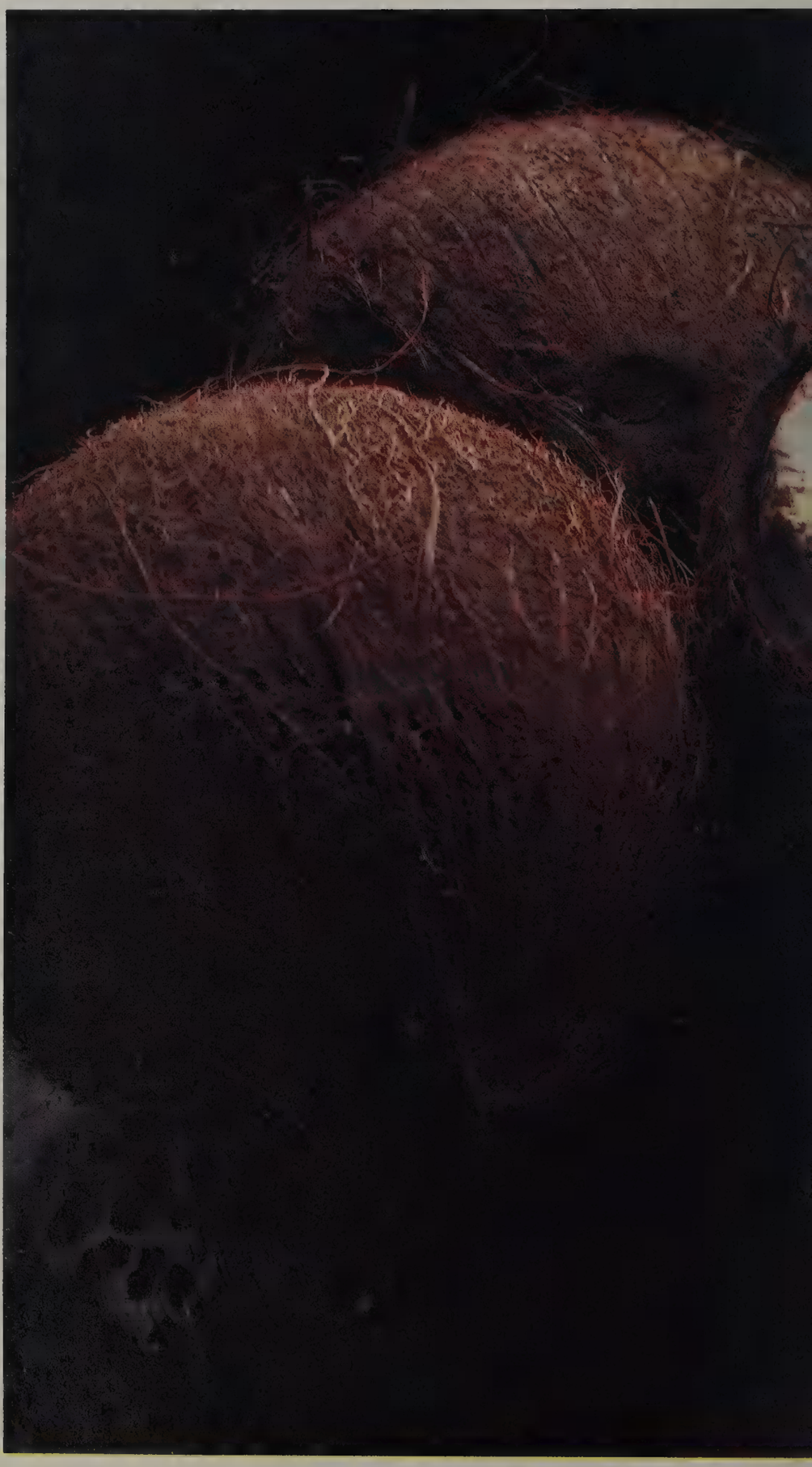
The Perilous Seed

Coconuts may be hazardous to your health

by Raymond Sokolov



The coconut is a very large seed that can kill. When I say this, I am not primarily thinking of people who have died accidentally when hit by a falling coconut. Nor do I have in mind the fatal accidents that inevitably result when harvesters going up into tall coconut palms fall to earth. Certainly, I was startled to read in 1982 that Major Julio de la Gente of the Philippine army had managed to detonate a bomb made entirely from residues of coconut oil. According to the official Philippine news agency, the 6.6-pound bomb, buried four feet under gravel near Zamboanga, blew debris as far as 656 feet and was described by Major de la Gente as "stronger than ordinary dynamite."

Such a device could obviously kill, but I have not subsequently heard reports of coco bombs exploding in U.S. embassies or otherwise supplanting dynamite or plastic. So I have tended to dismiss the de la Gente discovery as yet another Philippine gesture toward maximizing the use of a major local crop. This is an understandable preoccupation in a country so dependent on coconuts. Not long ago, plummeting coconut prices sent officials into a tailspin that had the prime minister, Cesar Virata, launching a campaign against imported U.S. junk foods and urging—on nutritional grounds—greater consumption of coconut oil and milk.

It is precisely on those grounds that all objective observers agree that the coconut is a dangerous seed. This is a difficult notion even for non-Filipinos to accept. From time almost immemorial, *Cocos nucifera* has charmed and delighted people with its stately fronds swaying high above tropical beaches. Writers of ancient Sanskrit called it *kalpa vriksha,* "the tree that provides all the necessities of life."

And with reason. The shells, the leaves, the wood, the fiber from the husk—all are useful, multifariously so. And it is no wonder that *C. nucifera* has been more widely planted than any other agricultural tree. But the age-old human enthusiasm for the coconut began and spread in what might be called palmier days, before we knew or had reason to care about cholesterol.

I hardly need to remind readers of *Natural History* that cholesterol and the satu-

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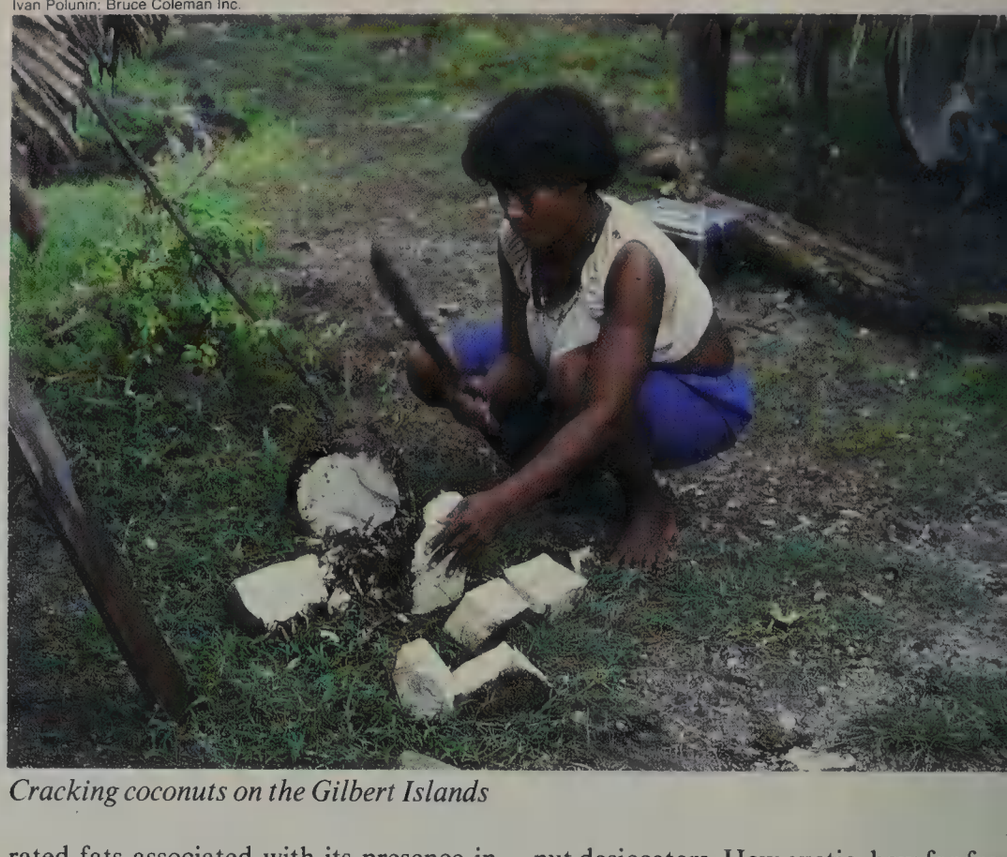

Cracking coconuts on the Gilbert Islands

rated fats associated with its presence in the cardiovascular system are openly condemned by almost everybody licensed to preach about diet and health. And since the oil that lurks in abundance in the white flesh of the coconut's kernel is lethally saturated, the coconut is currently anathema to right-thinking folk. Why even food writer Craig Claiborne, after expatiating last summer in the *New York Times* about a favorite Brazilian chicken recipe (*xin xin de galinha*) aslosh in the offending arboreal milk, felt obliged to warn his readers that it should be "reserved for special feasting. . . ."

I doubt that very many Americans run a serious risk of death because of daily meal plans chockablock with *xin xin de galinha* and other tropical dishes based on coconut milk. Those of you who have tasted these foods in Brazilian and Southeast Asian restaurants will understand the unctuous appeal of coconut milk. But a mass conversion of Manhattanites to the dangerous diet of Bahia or Zamboanga is a highly improbable catastrophe. Coconut oil is already found everywhere; it is an occult presence in the most mundane foods. The food industry adds it to numberless products, some of them labeled, others exempt from such revelation. Until recently, coconut oil was the leading edible oil (best known perhaps as a major constituent of margarine), but the more healthful soybean oil overtook it.

During the brief period of my misspent youth that I passed in the food news department of the *Times,* I was amused to receive periodic bulletins from a trade organization representing Philippine coconut desiccators. How exotic, how far from my daily concerns, I thought. But it is precisely those Filipino businessmen who dr and shred the coconut flesh (called copra to press out the coconut oil. And that o still competes with more expensive bu less saturated fats and oils for a place i many processed foods sold to unknowin Americans otherwise obsessed with the re silience of their aortas.

What is to be done?

I propose a two-pronged plan. First read labels on food packages closely an avoid products that list coconut oil (and it saturated cousin, palm oil) among the firs few ingredients. This is a tacit signal tha coconut oil is a major component of th food. Since you wouldn't have tasted th coconut in these industrial foods anyway you have lost nothing, except possibly a few pennies, and if you also keep you consumption of saturated fats—particu larly animal fats—low, you will have con tributed significantly to a sensible dietary program.

Now that you are a paragon of nutri tional caution, you can follow the second half of the plan with relative impunity. A Mr. Claiborne suggests, on festive occa sions you can afford to indulge in the gas tronomic delights of coco cuisine, thereby joining millions of people in other places who have developed hundreds of rich, fra grant, and perilous dishes that no one should miss—in moderation.

The coconut itself is the main obstacle to such enjoyment. Fortunately, you and don't have to remove the fibrous and bulky husk ourselves. Every supermarket carries husked coconuts. The spherical

wn, hairy shell is still there, but it is rel-ely easy to remove.

Having selected a coconut by the aural-ical method (make sure the shell isn't cked and that you can hear water slosh-around inside, indicating freshness), e it home and crack it.

f you like to drink the water, pierce a ıple of the coconut's eyes with an ice-k or a corkscrew and pour it through a ainer. (It is to these eyes—there are ee—that the coconut owes its name. anish explorers thought they looked e the eyes and nose of a monkey; Span-slang for monkey face was *coco.*) Oth-vise just crack the shell with a hammer. e water will drain away and the kernel l split into several large pieces. Nor-lly, it is no problem to pop the meat m the shell with a screwdriver. But if u heat the coconut in the oven before acking it (or afterward), the meat sepa-es from the shell even more easily.

Now you have the meat, but the meat s a coarse brown skin on it. If you were ending to serve the actual flesh, you uld have to cut away the skin with a getable peeler or a knife. This is unnec-sary and a waste of time if you are just tracting coconut milk. The skin does not lor or otherwise contaminate the milk. just cut the meat into pieces and rate" it in a food processor or blender. In the old days, you would have had to l away with a hand grater, but the metal ade of a processor is now the tool of oice. Soak the meat in three cups of iling water for a half hour and then pro-ss. Squeeze everything in the processor in a double layer of cheesecloth. That ll extract as much milk as is worth your hile. In the Third World they go back for econd extraction, and then a third, with pidly diminishing returns.

The white residue left after extraction is lled copra cake or poonac. You won't e it, but your dog might, in small nounts. Poonac is often used for animal dder in coconut-producing countries.

This extraction process is not as labori-s as it sounds. But you can avoid it alto-ther if you can find canned coconut ilk. In *The Classic Cuisine of Vietnam,* ach Ngo and Gloria Zimmerman recom-end a concentrated milk sold by Stan-od. Mrs. Ngo, a coconut connoisseur nose mother's garden in Vietnam had ur varieties of coconut growing in it—e for water, another for soft edible flesh, d so on—thinks canned milk is superior milk extracted from the less than ide-ly fresh kernels sold in this country.

Prepared coconut cream is also avail-le here, usually as an ingredient for ña coladas, but it will not work in recipes

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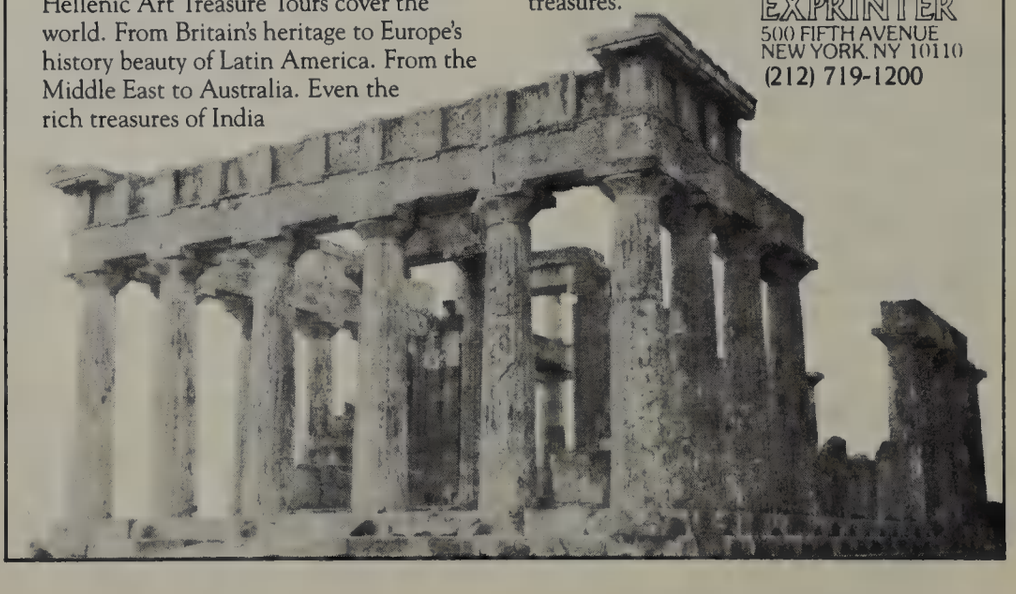
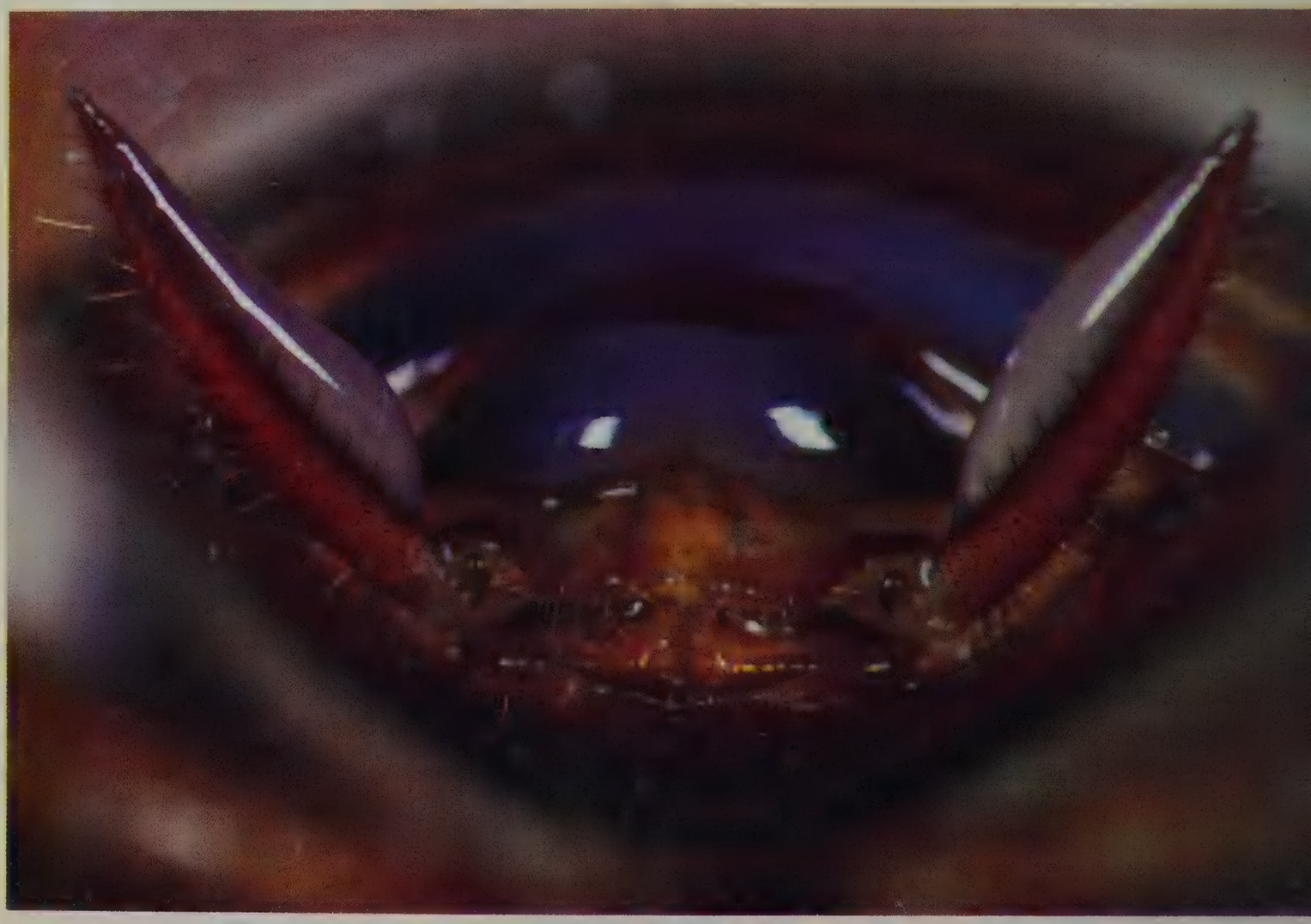




The Living End

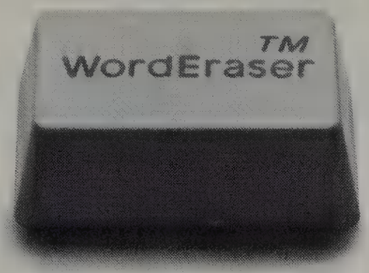
"A gremlin?" asked one observer. Another, noting the milky blue, thought of eyes. But entomologist Tom Eisner put an end to such foolishness. "It's a cockroach," he said. "A rear end shot."

Eisner explained how he obtained this dorsal fixation. "At the Archbold Biological Station in central Florida, you stay in cottages," he said, "and most of them have cockroaches. I consider them the majority group. This one crawled out onto the table where I was working. It was about an inch and a half long. I put some banana down on a piece of cardboard, and when it started to eat, I picked it up gently and carried it to the microscope."

It was a male *Periplaneta australasiae*, the Australian cockroach, and Eisner was particularly interested in the white, sugary looking substance on its posterior. "The white is a protei aceous slime," Eisner said. "It's like mucus, but it's very stick and also slippery. For an ant or spider that tries to grab bac there, it's a disaster. It would be like a person grabbing a gia tube of Duco cement."

Eisner took the shot at 3X magnification with a photoma roscope. The two blue semicircles (colored by the lighting) a the last two segments of the cockroach, which are both covere with the slime. The "ears" are cerci, or feelers, which are like pair of rear antennae. The tiny hairs on them can detect a movement—any sense of trouble approaching and the roac takes off.

Photograph by Tom Eisner



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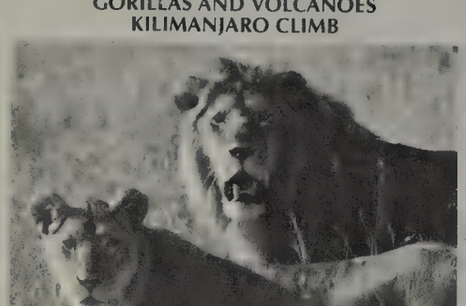

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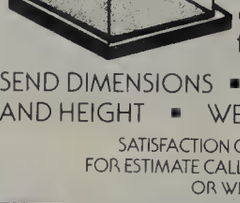

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Additional Read

Laxton (p. 42)

Few books or articles about Laxt have been published, and those that ha been are not readily available in this cou try. Some general accounts, however, pr vide a useful framework for understan ing the history of the village. For examp Richard Muir has written a great de about Britain's landscapes and towns, i cluding *The English Village* (New Yor Thames and Hudson, 1980), which boas lots of fine color photographs and d cusses towns like Laxton. Originally pu lished in the 1930s, *The Open Fields,* the husband-and-wife team of C.S. Orw and C.S. Orwin (Oxford: The Clarend Press, 1967), is the only book entire about Laxton. Complete and we documented, it is considered the standa work on the village. George C. Homans *English Villages of the Thirteenth Ce tury* (New York: Russell and Russe 1960) summarizes everyday life in med eval rural England, emphasizing the fie system, ways of working the land, ar what it was like to live on a manor. Th December 1980 issue of *The East Mi land Geographer* (vol. 7, part 6) is devote entirely to the open-field village Laxton. Write to the Department of G ography, University of Nottingham, No tingham, England NG7 2RD for more i formation about this publication. Finall *Laxton: An English Village* is a colo sound filmstrip that comes with an i structor's guide. About twenty copies a available from Donald Donihue, 203 We Wakefield Blvd., Winsted, CT 06098.

Siblicide (p. 54)

The research described in this article presented in greater detail in the March i sue of the *American Naturalist:* see Dou las W. Mock's "Siblicidal Brood Redu tion: The Prey-Size Hypothesis." Mock "Siblicidal Aggression and Resourc Monopolization in Birds," a more tech nical account of his experiment using fo ter parent birds, appeared in *Science* (vo 225, pp. 731–33). Stephen Jay Gould de scribes siblicide in a group of blue-foote boobies in the Galápagos Islands in "Th Guano Ring" (*Natural History,* Januar 1982, pp. 12–19). Mock's "Infanticid

blicide, and Avian Nestling Mortality" *Infanticide: Comparative and Evolu-nary Perspectives,* edited by Glenn usfater and Sarah Blaffer Hrdy, re-ws siblicide and brood reduction in all ds. The book discusses infanticide in a de range of animals, including fish, am-ibians, and primates.

rcupines (p. 62)

Although from time to time a short arti- appears on porcupines, few good, sub-ntial articles have been written about em for the popular audience. Two of the tter ones are "Porcupines" by J. C. cLaughlin (*Country Journal,* January 82, pp. 56–61) and "Equipped for Sur-al," by David Strohm (*National Wild-e,* October-November 1975, pp. 18–). The standard reference books on mmals contain short but accurate ac-unts; the best of these are in *Walker's ammals of the World,* by Ronald M. owak and John L. Paradiso (Baltimore: e Johns Hopkins University Press, 83), and in *Wild Mammals of North nerica,* edited by Joseph A. Chapman d George A. Feldhamer (Baltimore: e Johns Hopkins University Press, 82), which contains pertinent informa-n about the animal presented for a lay-an audience. Finally, both *Herbivores:*

hael Seidel

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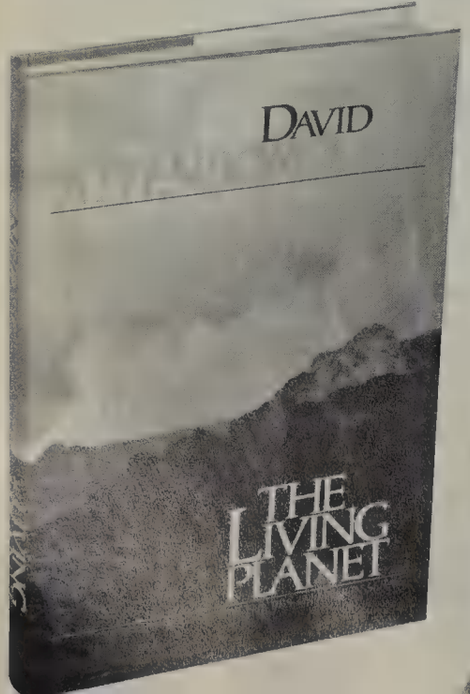

r Interaction with Secondary Plant abolites, by G.A. Rosenthal and Dan- H. Janzen (New York: Academic s, 1979), and *Variable Plants and bivores in Natural and Managed Sys-*, edited by Robert F. Denno and k S. McClure (New York: Academic s, 1983), discuss plant defenses nst herbivores.

ination by Rodents (p. 70)

he Principles of Pollination Ecology, K. Faegri and L. van der Pijl (New c: Pergamon Press, 1979, third edi-), is a comprehensive survey of the nical problems of pollination ecology roached from both a theoretical and ctical viewpoint. Introductory chap- review technical problems and draw parisons with spore dissemination in otograms (plants that bear no flowers seeds but propagate by means of es) and pollination in gymnosperms d plants whose ovules are borne on n scales). Following chapters deal with ination of angiosperms (flowering nts) and are divided into three parts: or- s involved in pollination, flower types, pollinator activities. B.J.D. Meeuse, nor of *The Story of Pollination* (New k: Ronald Press Co., 1961), says his k was written "for young persons be- en the ages of eight and eighty (and er)" and advises that "a sense of po- " will help "recapture the mood of dhood's constant wondering" about natural world. Meeuse, whose wonder- began while growing up in the "tropi- paradise" of West Java, has succeeded riting one of the best books on pollina- for nonscientists. He begins by pre- ting a number of principles concerning relationships between flowers and the mals that pollinate them; chapters in section look at the color vision of ani- ls, the ways in which flowers produce ir color effects, and the"honey guides" t lead pollinators to hidden nectar. He n proceeds to chapters on the most im- tant pollinators—bees, birds, butter- s, hawkmoths, flies, bats, and beetles. ry S. Perceval's *Floral Biology* (New k: Pergamon Press, 1965) is also writ- simply, with a minimum of technical ms. Perceval explores why pollination ecessary; the biology of flower parts; ncies of pollination, natural and ani- l; animal food in flowers, pollen, and tar; pollination by birds and insects l features of flowers pollinated by m; isolating and safeguard mecha- ms in flowers; and simple techniques l instruments for observing pollination rself.

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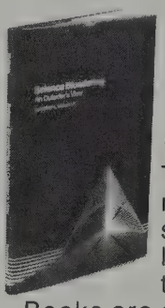

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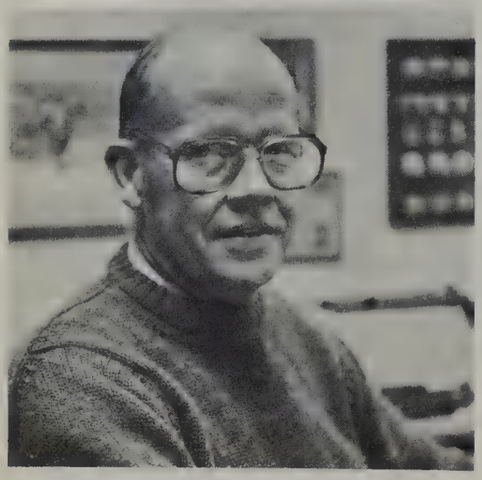
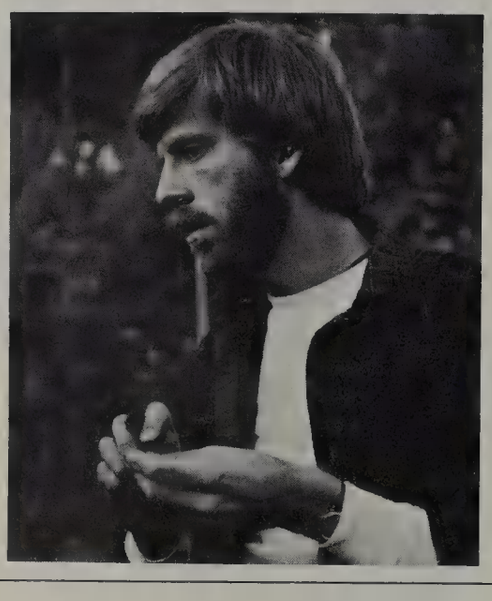
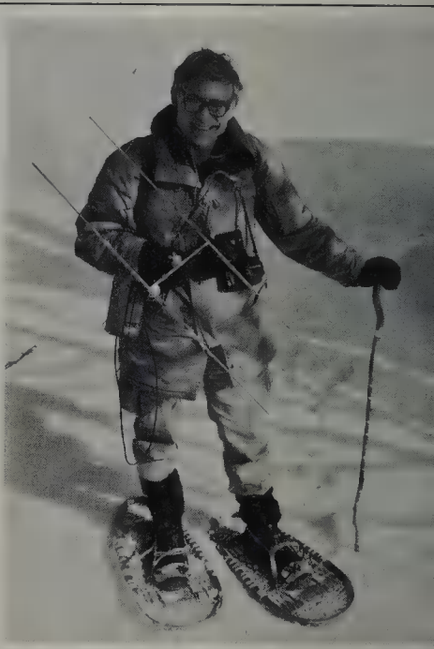


"Growing up in the San Joaquin Valley in California gave me an early appreciation for the native values of rural life," says **Donald D. Donihue** (page 42). "I was first introduced to the English village of Laxton while watching a documentary film entitled *The Medieval Village*." That was in 1970. For the next ten years, the film and its subject matter were "grist for the mill" in Donihue's sociology classes. In 1984, Donihue received a grant from the Exxon Education Foundation to produce a sound, color filmstrip about Laxton. Donihue is professor of sociology at Mattatuck Community College in Waterbury, Connecticut. He is now researching the history and social structure of a small community on Saint Kilda in the Outer Hebrides.

On a field trip to Texas six years ago to study monogamy in egret colonies, **Douglas W. Mock** (p. 54) learned that sibling rivalry among these birds was often fatal. That discovery led him to shift the focus of his research to avian siblicide. During the past fifteen years Mock has done fieldwork on a variety of birds in Minnesota, Oklahoma, Mexico, Venezuela, Panama, South Africa, and Quebec. He is currently on sabbatical from his position as associate professor of zoology at the University of Oklahoma. The youngest of four siblings, Mock says that has nothing to do with his interest in avian sibling rivalry.





Some scientists tie their interest their field of study to a season in ch hood; for others the interest popped later, perhaps under the steady influe of a teacher in graduate school. rarely can they do what **Uldis Roze** 62) can do—tell you the date and moment that they knew their work. was December 4 that I started with porcupines," Roze says. "Decembe 1978." It was the morning after the w ter's first big snowfall and Roze, com out of his cabin in the Catskills, saw mal tracks everywhere. He wande outside until he came upon a fat, w trail slithering off into the woods. It a porcupine trail—he knew that mu And spontaneously, he started follow it, across a stream, through a marsh a and then uphill. The animal's trail w along for a mile, occasionally pulling by hollow trees—it's looking for a d Roze realized excitedly—and then e ing at a big sugar maple with a twis crown. That was it. But somewh along the walk, watching and imagin the animal, admiring its persisten Roze had realized that he was going study this creature. Until then, U Roze was basically a lab man, trained pharmacology. But for the past six ye he has been following porcupines in Catskills, studying their ecology in forest and other topics. Roze teaches Queens College in New York.

"From my earliest recollections, I was interested in nature," says **Delbert Wiens** (p. 70). "All through school and for my first two years in college, I wanted to be a forester. But when I was a junior in college, I met a professor who talked me into going to graduate school and becoming a biologist." Wiens earned a Ph.D in botany at Claremont Graduate School in California with a thesis on the classification and chromosome relationship of mistletoes. Although he is well aware of the plant's folkloric aspects, the internal structure is what intrigues Wiens. "Mistletoe has beautiful chromosomes," he states. A professor of biology at the University of Utah, Wiens is now coauthoring a book on African mistletoe.

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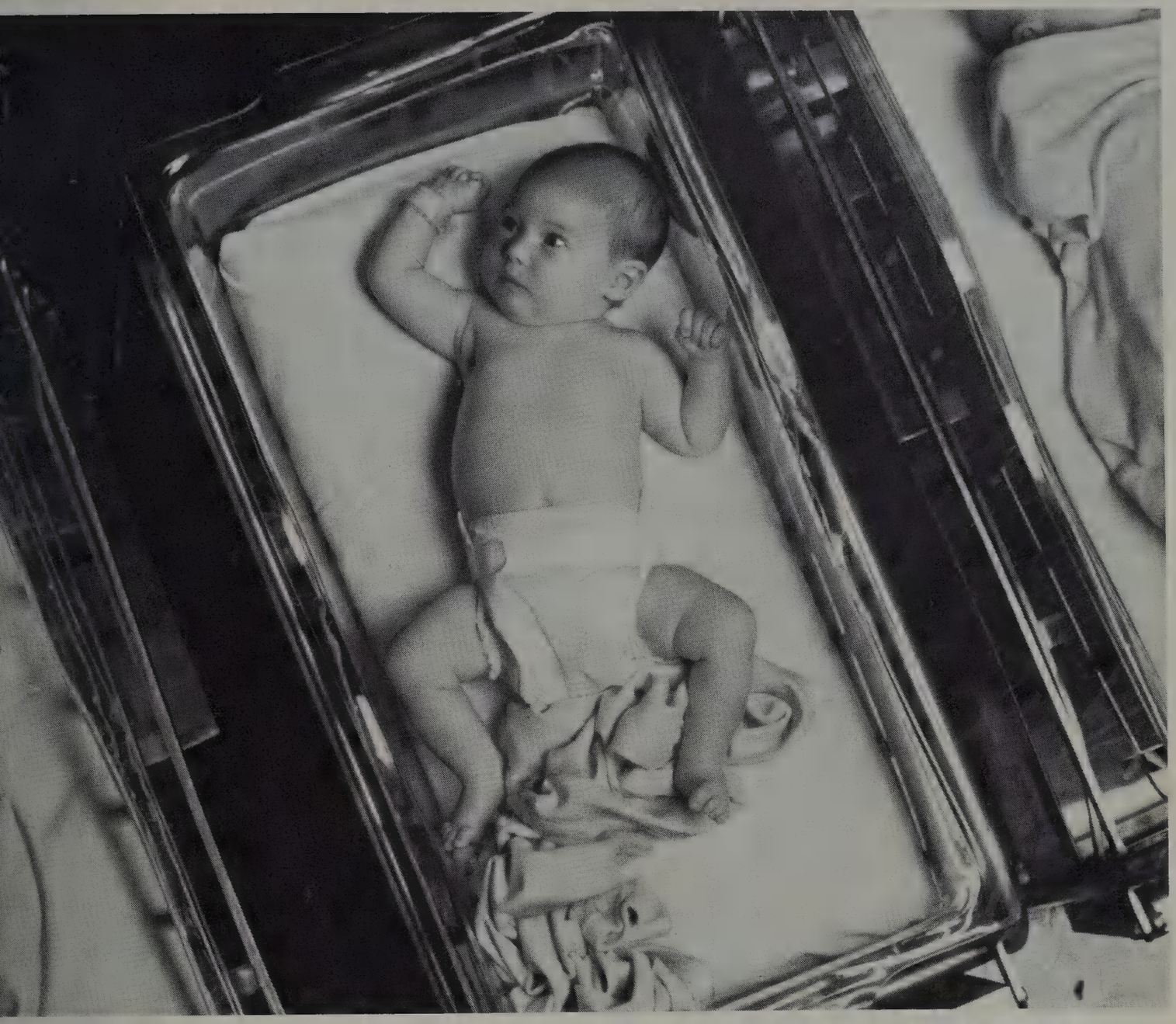

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ubscription Information (212) 690-0570

IATURAL HISTORY *(ISSN 0028-0712) is published monthly by the American Museum of Natural History, Central Park West at 79th Street, New York, N.Y. 10024. Subscriptions: $18.00 a year. In Canada and all other countries: $23.00 a year. Second-class postage paid at New York, N.Y. and at additional mailing offices. In Canada second-class postage paid at Windsor, Ontario (permit no. 9579).*

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Natural History *is indexed in* Reader's Guide to Periodical Literature.

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Rain Forest Villains

James D. Nations's essay ("Bearing Witness," March 1985) and Gertrude Blom's photographs were indeed effective at arousing anguish and indignation at the destruction of the Selva Lacandona and of the Lacandones, but laying the blame on greedy businessmen diverts us from our own complicity as beneficiaries of industrial civilization. How many of us lay our copies of *Natural History* down on our mahogany coffee tables and bemoan the loss of tropical rain forests? How many of us, to preserve a wild ecosystem, would give up all manufactured articles and live by hunting with bow and arrow? Can we expect the Lacandones to choose differently?

PETER SUNDT
Klondyke, Arizona

I read "Bearing Witness" with great interest. Certainly, the destruction of tropical rain forests, occurring throughout the entire world at an ever increasing rate, should be of concern to every educated person. But Nations neglects to mention that most of this destruction is being caused, not by an increase in population, but by policies originated by such entities as the International Monetary Fund and the World Bank. The World Bank, for example, has strongly encouraged the destruction of the Amazon rain forest by financing the building of highways and mines through equatorial Brazil. Nearly two centuries ago, President Jefferson asserted, "I truly believe that banking establishments are more dangerous than standing armies," and it is easy to see the truth of his observations even today.

CLIFTON WELLMAN
Sunnyside, New York

A Viper's Striking Distance

Reading Robert K. Colwell's account of a *Bothrops atrox* bite ("A Naturalist at Large," April 1985) brought to mind an encounter I had in June 1984 with a conspecific in Trinidad. In four visits to the island I have seen six specimens of *B. atrox* (called *mapepire balsain* on Trinidad), and with one exception, all were living close to human settlements. On an overnight hiking trip into the forest of the northern range I collected, photographed, and released without incident a specimen close to five feet in length. Several days later I was driving late at night in search of amphibians and reptiles. A small, two-foot specimen was stretched out on a wet blacktop road. Upon first examination, my companions believed it to have been hit by a passing car. However, when I slid a snake hook under its body, the snake began to move. For forty-five to sixty seconds I tried to direct it into an open bag, but the snake successfully avoided capture. It then did something totally unexpected. It was suddenly airborne toward me. A few backward steps and I was out of the snake's trajectory, but it was a full twenty-four to thirty inches off the pavement with its body parallel to the ground. I should point out here that the road was flat and the snake was not on an incline. The snake was soon bagged and was not examined until the following day. When it was removed from the bag the snake was dead; it had apparently been injured by a passing car before we found it.

There are sixty-one species of *Bothrops*. Several have the habit of jumping during a strike, but this behavior has not been well documented in *B. atrox*. Had the specimen I photographed a few days before performed a defensive leap, my experience could have been like Colwell's. *B. atrox* is widespread in the forests of South America, and naturalists would be well advised not to underestimate the striking distance of this species.

JOHN C. MURPHY
Plainfield, Illinois

Irish Corn and Haitian Breadfruit

In "The Great Breadfruit Scheme" (March 1985), Gerald and Selmaree Oster assert that in 1845, many Irish tenant farmers chose to starve rather than a
cept a British offer of maize to replace p
tatoes in their diet. This point wa
introduced by the authors to buttress the
assertion that Haitian slaves rejecte
breadfruit as a food because it was assoc
ated with their servile status in a strang
land. Since Irish tenant farmers were als
exploited, their refusal to accept maiz
would have been analogous to distaste fo
breadfruit among Haitian slaves. Hov
ever, no such rejection took place in Ir
land. The British offer of maize was mad
only halfheartedly, to say the least.

Cecil Woodham-Smith's *The Gre
Hunger* is an authoritative source on th
Irish famine of 1845–49. Woodham
Smith reports that in the spring of 184
after an initial period of resistance to th
strange new food, maize became im
mensely popular in the areas where it wa
available. Subsequently, difficulties i
transportation, storage, and milling, a
well as continued government refusal t
sponsor an adequate relief effort, kep
maize from reaching the starving masse
in rural western Ireland. In later year
when maize was somewhat more plentifu
many impoverished rural people were un
able to afford it even at low prices, sinc
they had virtually no income at all. Fear
ful of encouraging indolence, the govern
ment discouraged free distribution o
maize.

The millions who starved or were force
to emigrate from Ireland in the late 1840
did not do so because of distaste for maize
but because no significant relief effort wa
mounted when the harvest of their staple
the potato, was destroyed by blights.

THOMAS TILITZ
Jackson Heights, New York

In an otherwise interesting and infor
mative article, I was astounded to read
"To cultivate these cash crops profitably
slave labor was needed...." After al
these centuries, do we still have to take up
arms against this outrageous institution

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slavery? What kind of profits are these authors talking about?

JEREMIAH B. LIGHTER
New York, New York

Mass Extinctions and Opportunistic Survivors

Norman Myers ("The End of the Lines," February 1985) warns us that the creatures emerging from the swift annihilation of species that mankind is now perpetrating are likely to be "opportunistic," "clever," "generalist" species that adapt to a wide range of environments, multiply rapidly, and "often become pests. Examples include the English sparrow, the European starling, the housefly, the rabbit, the rat, plus many 'weed' plants." It is unfortunate that Myers failed to follow this thought to its proper conclusion: namely, that the species that will thrive *after* the coming mass extinctions may include one or more that are modeled on *Homo sapiens*—certainly the most opportunistic, clever, and generalist creature known to zoology and quite possibly the worst pest this planet will ever see.

ROBERT SCHMID
Hanover, New Hampshire

It seems to me that Norman Myers and others grant too much power to the human species to prevent the coming catastrophe. Myers demonstrates that Earth can only support a finite number of individuals in each ecological niche. To free all the niches that are impacted most severely, humans and those species we have chosen as our food and our pets would have to be reduced in numbers greater than birth control alone will accomplish. Is Myers suggesting that we should be willing to take such drastic measures to maintain the richness of species our current era enjoys?

If not, we must accept that the loss of some of the species we know today is inevitable. This is not to say that we should continue in our wanton ways, but rather that we should realize that our best efforts will not be enough to indefinitely preserve species that are already on their way out.

MARCELLA L. MURPHY
San Jose, California

The Clock of Evolution Needs Repair

Perhaps the reason that no one aside from Stephen Jay Gould ("This View of Life," April 1985) is proclaiming the message that molecular biology has solved *the* problem of the ages is because such is in fact not the case. For DNA hybridization distances to form an evolutionary clock they would have to be both additive and clocklike. They generally are not: Bonner, Heinemann, and Todaro showed that suc distances are not clocklike in lemurs ve sus other primates (*Nature*, 1980). As f additivity, Farris, in *Advances in Cl distics* (1981) and in *Cladistics* (1985 showed that molecular sequence diffe ences are not additive. As DNA hybri ization distances supposedly measure s quence differences, they are not additiv either. Since the premises underlying th method are incorrect, it has scarcely sep rated homology and analogy. Phylogen ticists do well to regard trees based upo such distances skeptically.

JAMES M. CARPENTE
Assistant Professor of Biolog and Assistant Curator in Entomolog Harvard Universi Cambridge, Massachuset

Stephen Jay Gould replies:

My esteemed colleague from upstai has not grasped the message of those wh labor in the bowels of his building. "*Th* problem of the ages," to which I referre in my column, cannot be the constructio of an "evolutionary clock," as Carpente asserts herein. After all, biologists befor 1859 were not evolutionists, but I do no exclude them from "the *ages*." My artic identified the central problem as th establishment of proper "relationships among organisms (identified as genealog cal since 1859, but attributed to a host o other reasons before). DNA phylogenie can, for the reasons I cited, determin these relationships by properly sorting ho mology from analogy for the first tim Whether or not these molecular distance form a clock is an interesting questio awaiting resolution, but not "the proble of the ages." In fact, my article was explic itly agnostic on this point. I ventured hope that the clock might work, but state that current evidence is far from conclu sive.

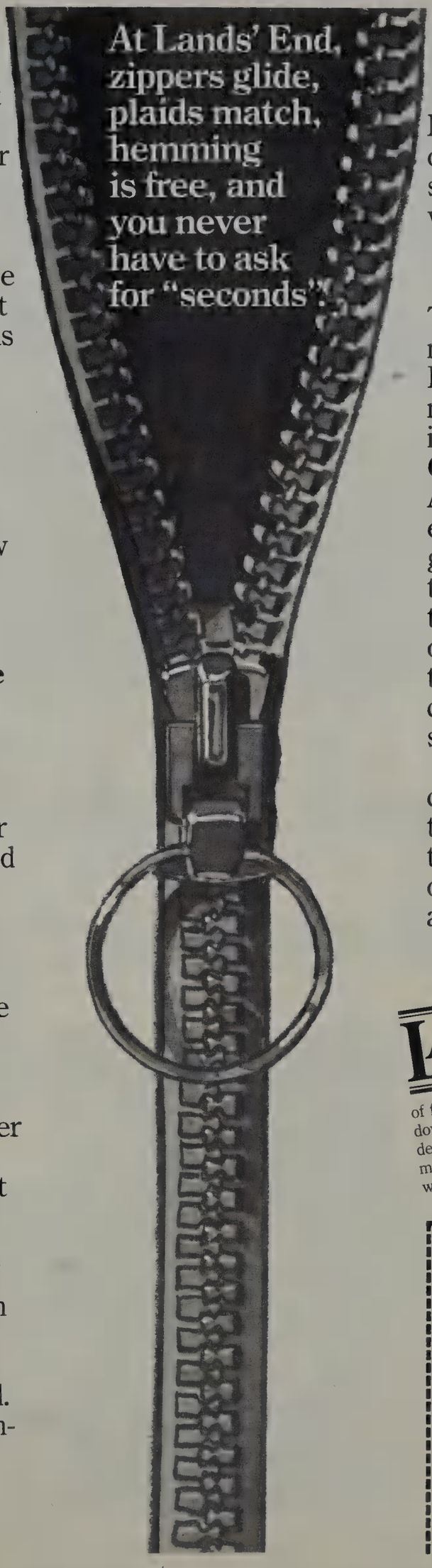
Baretta and William Blake

Look at page 71 of your March issue fo a second: ". . . a vision by Robert Blake' Robert? You mean Baretta? William brother possibly?

NANCY FERNANDE
New York, New Yor

Victor Scheffer and the editors meant, o course, William Blake, English poe painter, and engraver (1757–1827).

Erratum: On page 26 of our April 1985 i sue, the word *photographs* was inadve tently substituted for the word *portrait* giving the impression that George Catli (1796–1872) was a photographer rathe than a painter.



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Bluebird Belligerence

Ferocious fights between female eastern bluebirds may signal a clash of maternal strategies

by Patricia Adair Gowaty

A European colleague of mine recently called eastern bluebirds (*Sialia sialis*) the North American symbol of harmonious family life. Another writer has called them the most gentle and pacific of creatures. But despite their reputation for harmony and peace, my research indicates that bluebirds are often belligerent to individuals of other species as well as to other bluebirds. Aggression between bluebirds can be violent and dramatic, and what surprises many observers is that females are often fiercer fighters than males. Two, perhaps unrelated, questions—why females fight and why female aggression surprises theoreticians—interested me.

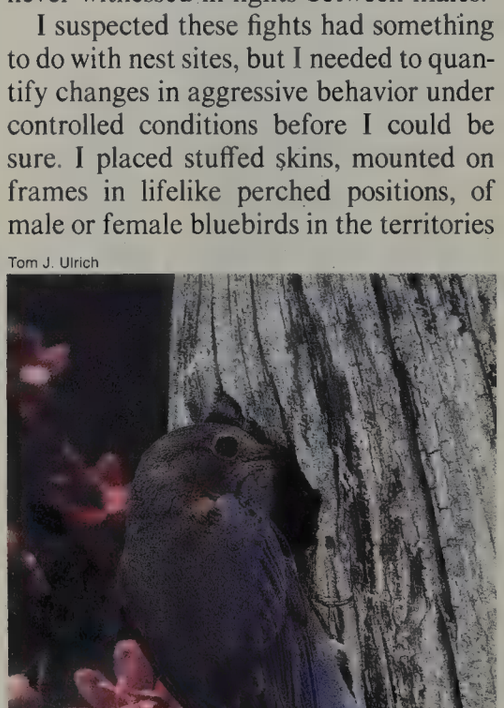
Bluebirds nest in cavities, and since the introduction and proliferation in North America of European starlings and house sparrows, which compete with bluebirds for nesting and roosting holes, eastern bluebirds have done almost all of their nesting in boxes built specifically for them. Most bluebird fights I have seen, whether with house sparrows or other bluebirds, seem related to this limited resource.

Like 90 percent of other bird species, bluebirds are sociographically monogamous—that is, one male and one female seem to interact primarily with each other, but their absolute fidelity cannot be confirmed. I studied bluebirds in northwestern South Carolina on 27,000 acres of farmland owned by Clemson University. In more than 95 percent of the 833 nesting attempts I observed, one male nested with one female. Females build nests and incubate the eggs, but the males—as in many songbird species—help feed the nestlings and fledglings. Both sexes defend their territory from other birds and guard against predators, but conflict between members of a pair is rare.

In early spring, males sing and chase away male territorial intruders. These chases sometimes end in attacks in which the birds grabble with their feet and flail at one another with their wings as they topple to the ground. Resident females that have procured nesting cavities also fight with female interlopers at this time. Females fight less often than males, but their battles are sometimes more fierce. I have seen female bluebirds maim and even kill each other, outcomes I have never witnessed in fights between males.

I suspected these fights had something to do with nest sites, but I needed to quantify changes in aggressive behavior under controlled conditions before I could be sure. I placed stuffed skins, mounted on frames in lifelike perched positions, of male or female bluebirds in the territories

Tom J. Ulrich



A female eastern bluebird

of breeding bluebirds. I counted all the reactions of the birds—physical attacks, dive-bombings, and vocalizations—for ten minutes. Later I compared frequencies of these actions in each stage of the nesting cycle—nest building and egg laying, incubation, and feeding of nestlings.

I found that male bluebirds are most aggressive to male interlopers (both living birds and models) during the nest building and egg laying stages. Male-to-male aggression tapers off during incubation and is almost nonexistent when nestlings are being fed. Even when nest building and egg laying occurred in June and July (relatively late), males were still belligerent, indicating that the change of season is not a cue to alter aggressiveness. And since I had presented the model to any pair only once during the season, I knew that the decrease in aggressiveness during the nesting cycle was not due simply to habituation to the models.

These observations left me with two evolutionary explanations for male-to-male aggression. First, a male might be guarding his mate, preventing her from copulating with another male. Such mate guarding is adaptive if it protects males from investing parental effort in another male's offspring. The mate-guarding explanation fits neatly with the evidence. Aggression hits a peak during nest building and egg laying, the times when copulations will produce offspring. Alternatively, aggressive bluebirds might be guarding their valuable nest sites, an adaptive behavior if—as I think is the case—bluebirds seldom or never breed successfully without access to nesting cavities. Cavity guarding would also explain the peak in aggression during nest building and egg laying, because nest sites are

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Male and female bluebirds: "Conflict between members of a pair is rare."

most vulnerable to takeover when few or no eggs or nestlings are present.

The pattern of female-to-female aggression resembled that of males; intense during egg laying, it was almost nonexistent after the eggs had hatched. But explaining this seemingly unusual female-to-female combativeness was more difficult. Perhaps resident females are guarding their nests from intruding females trying to lay eggs. Evidence in support of this hypothesis came from exclusion studies that, though designed to rule out paternity, enabled us to rule out mothers as well. A.A. Karlin (an ecological geneticist now at the University of Arkansas) and I began analyzing blood proteins of bluebirds in my study area to see whether some nestlings were in fact genetically unrelated to the adults caring for them. (The procedure is similar to the one commonly used to rule out human paternity.) Only a very small amount of blood is necessary to perform the test. In a process that seldom took more than five minutes, I captured the birds, bled them, and released them.

We tested blood in twenty-seven bluebird "families," that is, groups of nestlings and adults associating in single nest sites, and found that fully one-quarter of the families showed evidence of unrelatedness between adults and young. This outcome raised a number of questions. Under what circumstances, for instance, would an adult care for an unrelated hatchling? A male might do so if his mate had copulated with another male or if she had incubated the egg of an intruding female already mated to an outside male. When a resident female cares for an unrelated hatchling, there is usually only one explanation: an outside female has managed to lay an egg in the resident's nest. In this case, the resident male may or may not be the father. This second possibility was especially interesting to us because 15 percent of our female birds (but only 5 percent of males) took care of an unrelated nestling.

Could defense against intraspecific nest parasitism be the explanation for female-to-female aggression? I think so. Fights among bluebirds seemed most frequent and intense when nest parasitism was most likely to yield living offspring—when host females were laying eggs. Intraspecific nest parasitism also has been seen among other songbirds, particularly cavity nesters. Does something about nesting in holes predispose these species to high levels of "stolen" parentage? A bluebird cannot simply excavate a nest cavity the way a woodpecker can, and in recent years, starlings and house sparrows have increased the competition over already-made holes. Because bluebird nest sites are in short supply, perhaps the only way some females can successfully reproduce is to be opportunists—to lay their fertile eggs in nests holding some other bluebird mother's eggs.

It may also be that cavities and the nests they contain are easy for other birds to find, thus encouraging parasitism. Or it simply may be that ornithologists study cavity nesters more often than they do other birds, and therefore more frequently associate parasitism with cavity nesters.

Another puzzle remains: Why do bluebird fights occur only between individuals of the same sex? Shouldn't males also want to drive off females about to lay an egg already fertilized? One theory suggests that if a male is not aggressive to an intruding female, he may have a later opportunity to mate with her, thereby giving him the evolutionary advantage of producing extra offspring. Laboratory and field data have so far told us little about these possibilities, but I suspect that bluebird mating relationships will prove to be more complex than our theories have led us to believe.

Curiously, ornithologists have only recently begun to study nest parasitism within one species and to ponder its consequence—uncertain maternity. Could it be that we have ignored the potentially strong selective force of alternative female reproductive strategies because we are mammals, animals for which only paternity is questionable?

Patricia Adair Gowaty is research associate/assistant professor in the Department of Biological Sciences at Clemson University.

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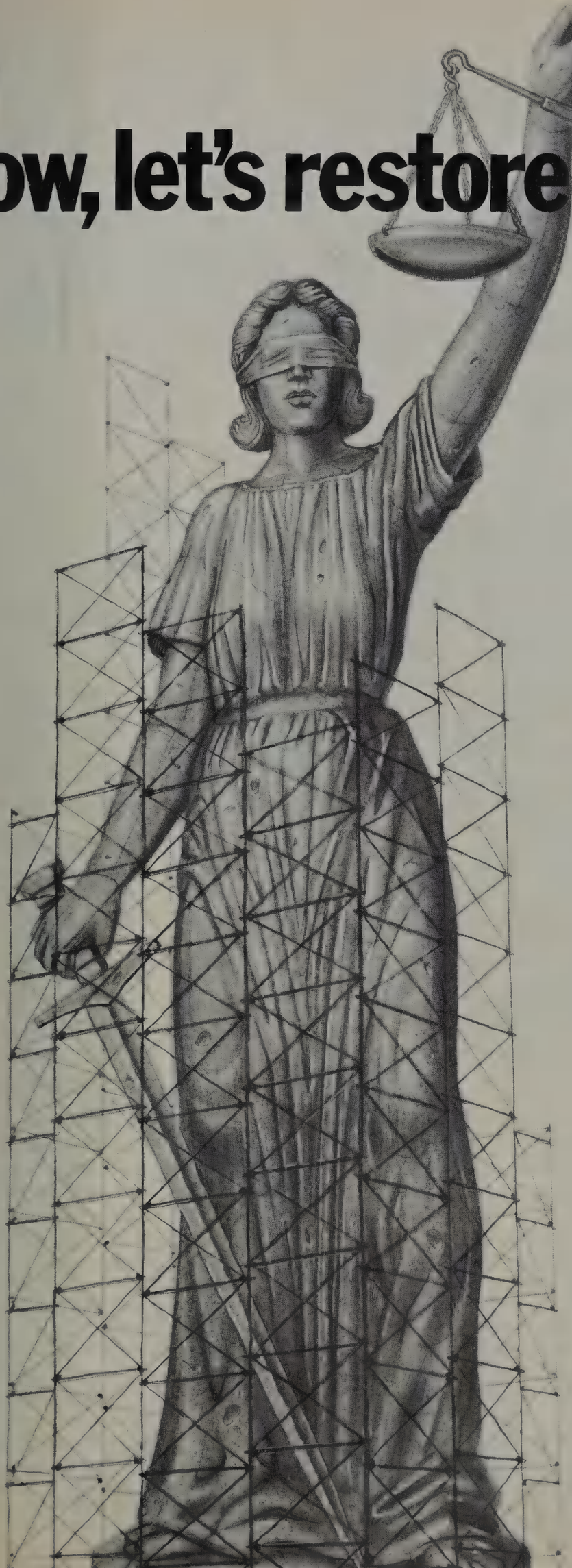

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Fleeming Jenkin Revisited

This obscure, but able, Victorian gentleman convinced Darwin himself on an important evolutionary point

by Stephen Jay Gould

The European revolutions of 1848 played a pivotal role in several famous lives. Karl Marx, exiled from Germany, published the last issue of his *Neue Rheinische Zeitung* in red, then moved to England, where he constructed *Das Kapital* in the reading room of the British Museum. The young Richard Wagner, espousing an idealistic socialism that he would later reject with vigor, manned the barricades of Dresden, then fled from Germany to avoid a warrant for his arrest and missed the première of *Lohengrin.*

Another man, destined for a lesser but secure reputation, experienced a touch of the same excitement. In February 1848, Henry Charles Fleeming Jenkin, a fourteen-year-old boy from Scotland, found himself in Paris surrounded by rebellion. He wrote to a friend in Edinburgh: "Now then, Frank, what do you think of it? I in a revolution and out all day. Just think, what fun!"

In 1867, the same Fleeming Jenkin would taste revolution of a different kind—this time as a transient participant, not a mere observer. In his much revised fifth edition of the *Origin of Species*, Charles Darwin made a substantial concession by admitting that favorable variations arising in single individuals could not spread through entire populations. (In retrospect, Darwin need not have conceded. He based his admission on a false view of heredity. In a Mendelian world, unknown to Darwin, such favorable variations can spread—see the subsequent discussion. Nonetheless, Darwin's concession represents a small but celebrated incident in the history of evolutionary thought.) Darwin wrote:

> I saw . . . that the preservation in a state of nature of any occasional deviation of structure . . . would be a rare event; and that, if preserved, it would generally be lost by subsequent intercrossing with ordinary individuals. Nevertheless, until reading an able and valuable article in the *North British Review* (1867), I did not appreciate how rarely single variations whether slight or strongly marked could be inherited.

Nearly every book in the history of evolution recounts the tale and refers to the author of this "able and valuable article" as "a Scottish engineer" or, more often, "an obscure Scottish engineer." The author was Fleeming (pronounced Flemming) Jenkin. Darwin, more explicit and vexed in private letters than in public texts, wrote to Joseph Hooker in 1869: "Fleeming Jenkin has given me much trouble. . . . "—and to Alfred Russel Wallace a few days later: "Fleeming Jenkin's arguments have convinced me."

All evolutionists recognize (and mispronounce by excessive literalism) Fleeming Jenkin as the man who forced an explicit, though unnecessary, concession from Darwin, but we know nothing about him and tend to assume he rose from general obscurity for one small moment in our sun—a lamentable parochialism on our part.

My own career has included two fortuitous and peculiar intersections with Fleeming Jenkin—so I decided that I must write a column about him now, before a third encounter elevates coincidence to inescapable pattern. I was an undergraduate at Antioch College from 1958 to 1963. Antioch was (and is) a wonderful school in the finest American tradition of small liberal-arts colleges. But it doesn't boast much in the way of library facilities for scholarship based on original sources. One day in 1960, I was browsing aimlessly through the stacks and found a crumbling run of the *North British Review* for the mid-nineteenth century. I recognized the name from Darwin's citation and my heart skipped a beat as I hoped against hope that the volume for 1867 lay within the series. It did, and I then spent a more anxious minute convinced that I had the wrong title or that the issue for the right month would be missing. It wasn't. I found Jenkin's article and rushed to the pre-Xerox wet processor (anachronistically named smellox by a friend of mine a few years later, in honor of the unpleasant chemical that left its signature even after drying). I fed dimes into the machine and soon had my precious copy of the original Fleeming Jenkin. What a prize I thought I had. I was sure that I possessed the only copy in the whole world. (Can you imagine what one peek at the Harvard library does to such naiveté?) I have carried that copy with me ever since, assigning it to properly Xeroxed offspring to classes now and again, but never dreaming that I would write anything about Jenkin.

Then, last month, I was browsing through a friend's Victorian literature collection, aimlessly running my eye along the titles of Robert Louis Stevenson's complete works. I found *Treasure Island, Kidnapped,* and all the other items of my old "Author's" card game. But my heart skipped another beat at the next title, *Memoir of Fleeming Jenkin.* The "obscure Scottish engineer" had achieved sufficient renown (in areas far from my own parish, where he only dabbled, however successfully) to win a full volume from Stevenson's pen. I kicked myself for sectarian assumptions in the granting of "importance," vowed to learn more about Jenkin (and to tell my fellow evolutionists), and raided the stacks of Widener Library, where I found several copies of Stevenson's memoir, amidst (no doubt) a liberal sprinkling of *North British Re*

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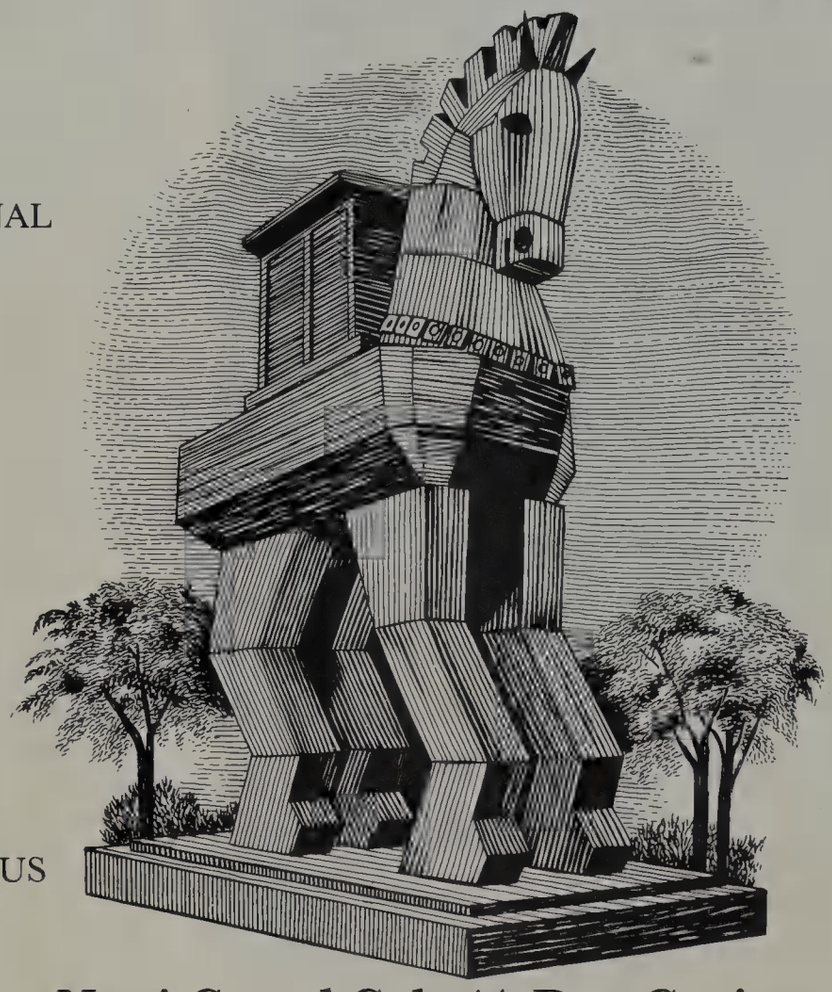

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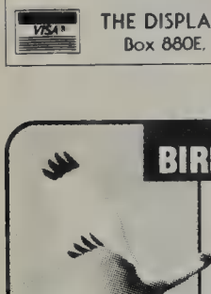

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views for 1867 (which, *smelloci gratia*, I didn't need).

An interesting man, Fleeming Jenkin—and made all the more appealing by the strength of Stevenson's prose. Jenkin spent most of his life in Edinburgh, where he campaigned for the improvement of home sanitation, conducted some of Britain's first experiments with the phonograph, produced and directed amateur theatricals, hated golf (about as bad as barfing on apple pie in those parts), and became the first professor of engineering at the University of Edinburgh. Most importantly, he was a close friend and colleague of Lord Kelvin and spent most of his career designing and outfitting transoceanic cables with the great physicist.

Stevenson's book has a lovely, archaic charm. It describes a moral perfection that cannot be, and belongs to the genre of guiding homilies based on lives of the great. If Jenkin ever gazed at a woman other than his wife, if he ever raised his voice in anger or acted in even momentary pettiness, we are not told. Instead, we get glimpses of a simpler and formal world based on unquestioned certainties and perhaps better past. In 1877, Jenkin writes to his absent wife about their son: "Frewen had to come up and sit in my room for company last night and I actually kissed him, a thing that has not occurred for years." The Captain, Jenkin's aged father, dies at age eighty-four but achieves solace in his last hour from a false report on the rescue of General "Chinese" Gordon at Khartoum: "He has been waiting with painful interest for news of Gordon and Khartoum; and by great good fortune, a false report reached him that the city was relieved, and the men of Sussex (his old neighbors) had been the first to enter. He sat up in bed and gave three cheers for the Sussex regiment."

Stevenson's memoir contains exactly one line on Jenkin's 1867 foray into evolutionary theory: "He had begun by this time to write. His paper on Darwin . . . had the merit of convincing on one point the philosopher himself." Evidently, Jenkin needed neither evolution nor the *North British Review* to merit Stevenson's extended attention. I felt a bit ashamed at my own previous parochialism. Do grocers know Thomas Jefferson only as the man who invented that thing that gets the cereal boxes down from the top shelf?

The backward reading of history, known to professionals as the Whiggish approach (in dubious honor of those Whig historians who evaluated their predecessors exclusively by their adherence to ideals of Whig politics unknown in their times), has cruelly misserved many fin thinkers, Jenkin included. Several of m essays try to rescue scientists I respec from this mistreatment. Of the grea *Prodromus* of Nicolaus Steno, the found ing document of geology, for example most students learn only that it estab lished the law of the "constancy of interfa cial angles" in crystals. I read the *Prodro mus* a half dozen times and could neve find the reference. Finally, I located th law as a throwaway comment in a figur caption—where it plays no role whateve in the development of Steno's argumen The *Prodromus* is a brilliant taxonomi treatise that establishes rules of reasonin in geology by correctly classifying soli objects found within other solids (crystal in rocks, fossils in strata, for example), an it must be viewed on its own terms an purposes if we wish to understand Steno' genius (see my essay of May 1981).

Jenkin has suffered because commen tators extract from his 1867 article jus the one small point that provoked Dar win's concession—and then analyze it i modern terms by pointing out that a twen tieth-century Darwin could stick to hi Mendelian guns. No modern evolutionar biologist, to my knowledge, has ever con sidered Jenkin's argument as a whole an appreciated its force, despite its errors i modern terms. I shall attempt this rescu but bow first to the constraints of histor and discuss the point that secured Jenkin' slight renown in evolutionary circles.

Darwin and Jenkin accepted the usua notion of heredity prevalent in the times—a concept called blending inher tance. Under blending inheritance, th offspring of two parents tend to lie hal way between for inherited character Jenkin pointed out to Darwin, or so th usual and quite inadequate story goe that blending inheritance would challeng natural selection because any favorabl variant would be swamped out by back breeding with the predominant parenta forms. Jenkin's own example will mak the point clear. It also serves as a sad re minder of the unquestioned racism of Vic torian England—and as an indicatio that, for all our pressing problems, w have improved somewhat during the pas century:

> Suppose a white man to have been wrecke on an island inhabited by negroes. . . . Su pose him to possess the physical strengt energy, and ability of a dominant white rac . . . grant him every advantage which w can conceive a white to possess over the na tive. . . . Yet from all these admission there does not follow the conclusion tha after a limited or unlimited number of ge erations, the inhabitants of the island wi

white. Our shipwrecked hero would obably become king; he would kill a great any blacks in the struggle for existence; would have a great many wives and chil- en, while many of his subjects would live d die as bachelors. . . . In the first genera- on there will be some dozens of intelligent ung mulattoes, much superior in average telligence to the negroes. We might ex- ct the throne for some generations to be cupied by a more or less yellow king; but n any one believe that the whole island ll gradually acquire a white, or even a yel- w population. . . . for if a very highly fa- red white cannot blanch a nation of ne- oes, it will hardly be contended that a mparatively dull mulatto has a good ance of producing a tawny tribe.

In other words, by blending inheritance, e offspring of the first generation will be ly half white. Most of these, since full acks so greatly predominate (and follow- g prohibitions against incest), will marry ll blacks, and their offspring of the sec- d generation will be one-quarter white. the same argument, the proportion of hite blood will dilute to one-eighth in the ird generation and soon dwindle to obliv- n, despite its putative advantages.

Darwin, or so the story goes, saw the rength of this argument and retreated in ustrated impotence toward the La- arckian views that he had previously re- cted. Whiggery then comes to the res- ue. Inheritance is Mendelian, or "parti- ulate," not blending (though Darwin ed long before the rediscovery of Men- el's laws in 1900). Traits based on genetic utations do not dilute; genes that deter- ine such traits are entities or particles at do not degrade by mixing with genes the other parent in offspring. Indeed, if cessive, a favorable trait will appear in offspring of the first generation (in atings between the favored mutant and dinary partners carrying the dominant ene). But the trait does not dilute to obliv- n. In the second generation, one-quarter the offspring between mixed parents ll carry two doses of the favored reces- ve gene and will express the favored ait. Any subsequent matings between ese double recessives will pass the fa- red trait to all offspring—and it can read through the population if concen- ated by natural selection. (Skin color d height seem to blend because they are termined by such a large number of par- culate genes. The average effect may be blend, but the genes remain intact and bject to selection.)

But this usual story fails when we prop- ly locate Jenkin's point about blending the wider context of an argument that rvades the entire essay—and do not mply extract it as a kernel deserving

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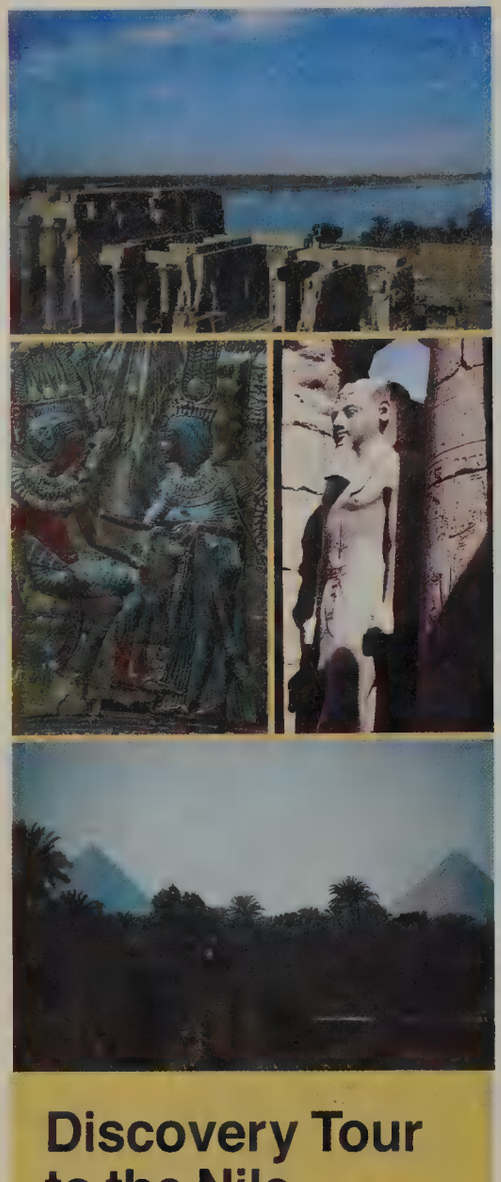

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modern notice while discarding the rest as chaff. As historian Peter J. Vorzimmer notes in his excellent book, *Charles Darwin: The Years of Controversy* (Temple University Press, 1970), Jenkin presented his arguments about blending in discussing only one particular kind of variation—*single* favorable variants *substantially different* from parental forms.

Darwin was no fool. He had thought about variation as deeply as any man. His longest book, the two-volumed *Variation of Animals and Plants Under Domestication* (1868), summarizes everything he and almost everyone else knew about the subject. Can we seriously believe that he had never thought about problems that blending posed for natural selection, that he needed a prod from an engineer to recognize the difficulty? As Vorzimmer shows, Darwin had pondered long and hard about problems provoked by blending. Jenkin did not introduce Darwin to this basic problem of inheritance; rather, he made a distinction between the kinds of variation that blending affects, and Darwin welcomed the argument because it reinforced and sharpened one of his favorite views. Darwin did not retreat before Jenkin's onslaught, but rather felt more secure in his preferred belief—hence his expressed gratitude to Jenkin and hence (I assume) Stevenson's single comment that Jenkin had convinced "on one point the philosopher himself." Stevenson, the novelist, understood. We have forgotten.

The real issue has been lost in a terminology understood in Darwin's time but no longer familiar. Let us return to Darwin's letter to Wallace, quoting the passage this time in full: "I always thought individual differences more important than single variations, but now I have come to the conclusion that they are of paramount importance, and in this I believe I agree with you. Fleeming Jenkin's arguments have convinced me."

In Darwin's time, "individual differences" referred to recurrent variations of small scale, while "single variations" identified unique changes of large scope and import—and often called "sports." Debate had long focused on whether small-scale and continuous, or occasional and larger, variations supplied the raw material for evolutionary change. Darwin, the quintessential continuationist of this or any other age, had long preferred recurrent small-scale changes but had continued to flirt (largely by weight of tradition) with larger sports. Now, the simple point of Jenkin's argument: Note that he speaks of *one* white man identified (in the racist tradition) as vastly superior to the natives—in other words, a single sport. Jenkin's famous blending argument is only about single, marked variations—not about the continuous recurrent variations that Darwin preferred. By accepting Jenkin's view, Darwin could finally rid himself of a form of variation that he had never favored.

As for recurrent, small-scale variation (individual differences, in Darwin's terminology), blending posed no insurmountable problem, and Darwin had resolved the issue in his own mind long before reading Jenkin. A blending variation can still establish itself in a population under two conditions: first, if the favorable variation continues to arise anew so that any dilution by blending can be balanced by new appearances, thus keeping the trait visible to natural selection; second, if individuals bearing the favored trait can recognize each other and mate preferentially—a process known as assortative mating in evolutionary jargon. Assortative mating can arise for several reasons, including aesthetic preference for mates of one's own appearance and simple isolation of the favored variants from normal individuals. Darwin recognized both recurrent appearance and isolation as the primary reasons for natural selection's continued power in the face of blending.

With this background, we can finally exhume the real point and logic of Jenkin's essay—an issue still very much alive, and discussed (through all his factual errors) in a most interesting and perceptive way by Fleeming Jenkin. Jenkin's essay is a critique of Darwin's continuationist perspective—his distinctive claim, still maintained by the evolutionary orthodoxy—that all large-scale phenomena of evolution may be rendered by accumulating, through vast amounts of time, the tiny changes that we observe in modern populations. I call this conventional view the "extrapolationist" argument; I also share Jenkin's opinion (but for different reasons) that it cannot suffice. I find it supremely ironic that the one small section of Jenkin's article *not* about Darwin's claim for continuity (his argument that single sports will be swamped by blending) has become the only part that we remember—and, to make matters worse, usually misinterpret. Such, however, is the usual fate of Whig heroes and villains (see my previous essays on Steno, Hutton, Cuvier, and Gosse).

A simple, almost pedantic, précis of Jenkin's argument should rescue his larger point. Jenkin's essay proceeds in four parts. The first, on limits of variation, admits that Darwin's favored style of recurrent, continuous variation does occur and can be manipulated by natural selec-

ion to change the average form of a species. But, Jenkin argues, such variations always fiddle in minor ways with parts already present; they cannot construct anything new. Thus, natural selection can make dogs big, small, blocky, or elongated—but it cannot turn a dog into something else. Jenkin expresses this argument in his powerful metaphor of the "sphere of variation." Natural selection may move the average form anywhere within the sphere, but not beyond its fixed limits:

A given animal or plant appears to be contained, as it were, within a sphere of variation; one individual lies near one portion of the surface, another individual, of the same species, near another part of the surface; the average animal at the center.

Common experience, Jenkin affirms, supports his view. Artificial selection practiced by breeders proceeds rapidly at first but soon reaches frustrating limits. Jenkin writes of racehorses:

Hundreds of skillful men are yearly breeding thousands of racers. Wealth and honor await the man who can breed one horse to run one part in five thousand faster than his fellows. As a matter of experience, have our racers improved in speed by one part in a thousand during the last twenty generations?

Darwin, Jenkin claims, maintains an unwarranted faith in the power of simple time to overcome these barriers:

The difference between six years and six myriads, blinding by a confused sense of immensity, leads men to say hastily that if six or sixty years can make a pouter out of a common pigeon, six myriads may change a pigeon to something like a thrush; but this seems no more accurate than to conclude that because we observe that a cannon-ball has traversed a mile in a minute, therefore in an hour it will be sixty miles off, and in the course of ages that it will reach the fixed stars.

Darwin might argue, Jenkin admits, that once a species reaches the limit of its glass sphere, time will eventually reconstitute this edge as a new center and produce a new sphere around the previously peripheral point. Jenkin also rejects this argument:

The average or original race . . . will [in Darwin's view] spontaneously lose the tendency to relapse and acquire a tendency to vary outside the sphere. What is to produce this change. Time simply, apparently. . . This seems rather like the idea that keeping a bar of iron hot or cold for a long time would leave it permanently hot or cold at the end of the period when the heating or cooling agent was withdrawn.

Jenkin's second section, on types of

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variation, begins by admitting Darwin's point that small-scale recurrent variations will not be destroyed by blending. But these are the very variations subject to strict limits by the previous argument about rigid spheres. What kind of variation might then induce the evolution of something substantially new? Single sports might seem promising, but these are the rare events that will be swamped by blending—and readers may now note where the only bit of Jenkin that we remember lies within his general argument. But perhaps some kinds of sports do not blend but do perpetuate their kind. Fine, Jenkin admits. Perhaps such creatures do occasionally arise and produce new species. But such a process is not Darwinian evolution, for Darwin insisted that natural selection acts as a creative force by gradually accumulating favorable variants. Indeed, would such a process be very different from what the vernacular calls "creation"?

The third part argues that even if Darwin could find (which he can't) some way to accumulate small-scale recurrent variations into something new, geology does not supply enough time for such a slow process. Here Jenkin relied on the false arguments of his dearest friend, Lord Kelvin, about the earth's relatively young age (see my column of October 1983).

The last section presents a powerful (and I think entirely correct) argument about the difficulty of inferring historical pathways from current situations. Jenkin contends that nearly any static situation can arise via several historical routes; thus the situation by itself cannot specify the pathway. Jenkin points out that Darwin bases much of his argument upon the lack of definite boundaries in nature—the intergradation of species into species, or geographic region into region. Darwin's continuationism predicts just such an absence of boundaries since species are gradually and imperceptibly changed into their descendants, while a creator should leave gaps between his incarnated objects. But Jenkin argues that many natural items come as continua, yet clearly do not arise by a process of historical transformation. Arguing, as he always did, by metaphor and analogy, Jenkin writes:

> Legal difficulties furnish another illustration. Does a particular case fall within a particular statute? Is it ruled by this or that precedent? The number of statutes or groups is limited; the number of possible combinations of events almost unlimited.

Taken as an entirety, Jenkin's argument possesses a kind of relentless logic. The critique of Darwin's extrapolationism serves as its unifying theme. Part one argues that small-scale variation cannot extend beyond fixed limits. Part two claims that no style of variation can make something substantially new in a Darwinian world. Part three proposes that even if Darwin could find a way, geology does not permit enough time. Finally, part four holds that we cannot infer historical transformations from the admitted continua of nature.

I don't want to fall into a Whiggish pit and judge Jenkin by current standards (everything that has gone before in this essay adequately discharges, I hope, my dues to anti-Whiggery). But old arguments usually repay our close attention because we often stop discussing the fundamentals once an orthodoxy triumphs, and we need to consult the original debates in order to rediscover the largest issues—perhaps never really resolved but merely swept under the rug of concord. Much of Jenkin's argument fails today, for few things last a century in science. He was clearly wrong about blending in part two and about time in part three. But I believe that he was right about continua in part four and that we are still plagued by our tendency to make an almost automatic inference about history when we fail to find clear boundaries.

The first argument about limits of variation has also risen again in current debates about evolutionary processes. I don't accept Jenkin's metaphor of the sphere because small quantitative changes can accumulate to qualitative effects or leaps (contrary to Jenkin's position), and because I accept Darwin's argument that new spheres can be reconstituted about previously peripheral points.

But neither (probably) is a species the kind of almost equipotential sphere that the strict Darwinians envisaged—unconstrained and capable of rolling anywhere that natural selection pushes. The constraints imposed by genetics and development have emerged as a central topic in contemporary evolutionary debate—and Fleeming Jenkin did present an insight worth considering.

In short, and for many reasons that I can't begin to discuss at this advanced length (but have treated in many previous columns), Darwin's strictly extrapolationist vision may not describe large-scale evolution very well—small, local adaptations built in the refiner's fire of Darwinian competition among organisms struggling for reproductive success may not, by extension, explain trends that persist for millions of years or relays of changing diversity that mass extinctions produce. Jenkin, who presented the most logical dissection of Darwin's continuationist vision in 1867 does reach across a century to set us think ing, however superannuated his specific claims.

We may give the last word to Jenkin via Robert Louis Stevenson. One day as a young man, Stevenson reports, Fleeming Jenkin argued bitterly with two young women about a pressing issue of Victorian hypermorality; can a misdeed agains moral codes ever be condoned, whatever the circumstances—stealing a knife to prevent a murder, for example? (Jenkin to his credit, argued the affirmative.) As he left the house, his anger mellowed. He realized that even the most apparently pe culiar belief deserves respect if argued honorably and if properly constructed upon a set of basic premises different from those usually cherished:

> From such passages-at-arms, many retire mortified and ruffled; but Fleeming had no sooner left the house than he fell into de lighted admiration of the spirit of his adver saries. From that it was but a step to ask himself 'what truth was sticking in thei heads'; for even the falsest form of words (in Fleeming's life-long opinion) reposed upon some truth.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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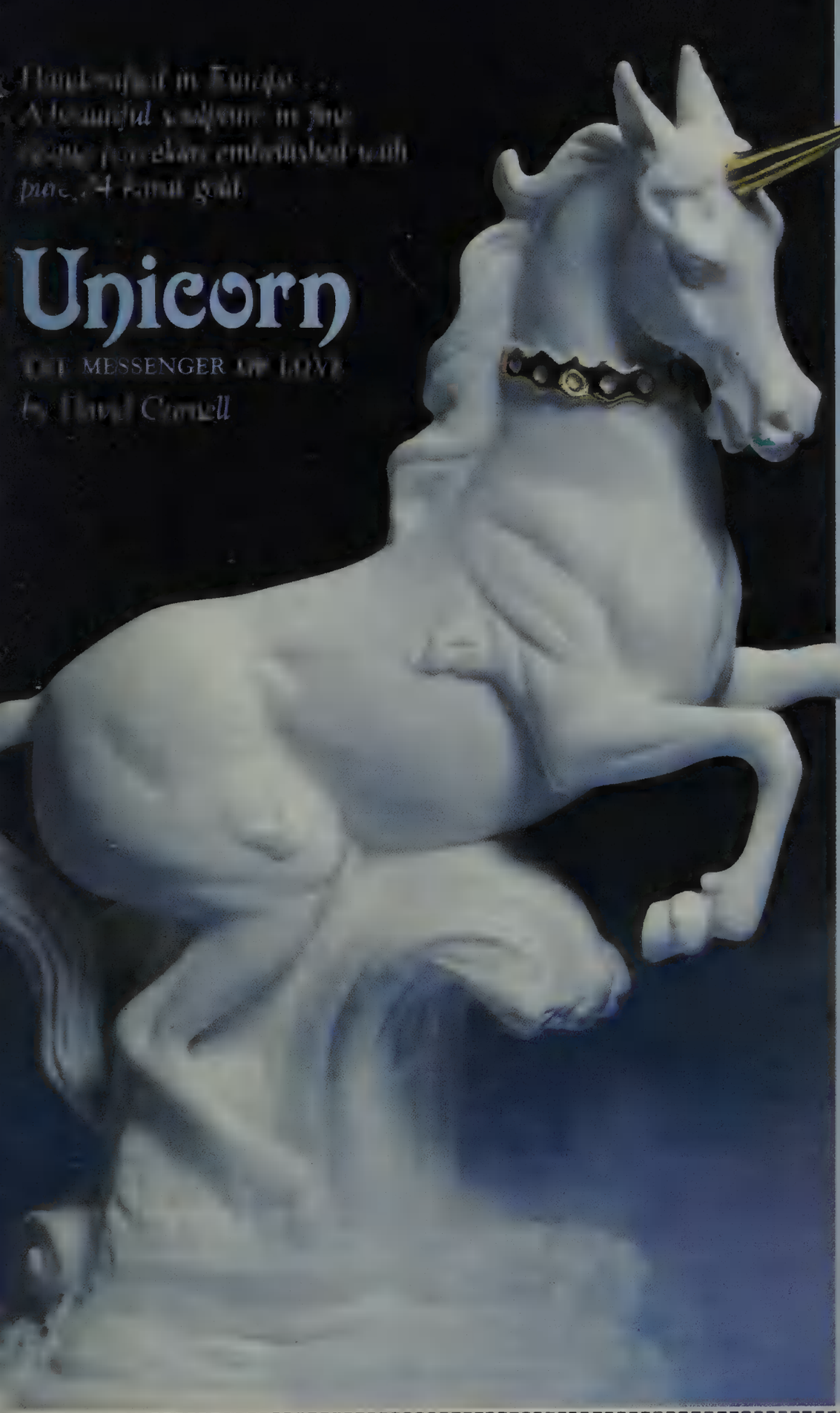

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One Potato, Two Potato

Their methods may be scorned, but Newfoundland's gardeners haul in the vegetables

by John T. Omohundro

In recent years, painstaking fieldwork in anthropology has often uncovered a reasonableness, even an ingenuity, in the apparently cloddish methods of the tribal yam gardener or peasant maize farmer. To discover that such farmers were outstanding in their fields, ethnographers have been standing out in the fields with them. And there they clocked the farmers' work time, weighed their harvests, photographed their techniques, and in general submitted their actions to a plethora of measurements designed to assess efficiency and productivity. There is an intelligence, they found, in the customary ways. Food-getting practices, because they immediately affect survival, seem particularly susceptible to a kind of vigorous selection over the years. How we, or the Papua New Guineans, feed ourselves, is not an arena where stupidity could long be tolerated.

No situation better illustrates this notion of peasant wisdom than the lazy beds on the Island of Newfoundland, in eastern Canada. "Lazy beds" is the term commonly used to describe the gardens Newfoundlanders create to grow their winter's supply of potatoes, turnips, onions, and cabbage. The name derives from "lazy root," the English epithet for the potato, which was so common in Ireland and the poor regions of Britain from where Newfoundland's settlers came. The lazy bed results from laying the seed on the surface of the ground and spading soil over it, creating alternating trenches and raised ridges, or beds. The beds are produced with only a few hand tools and tended little between planting and harvesting.

Beginning in the eighteenth century, families left their home districts of Dorset, Waterford, or the Channel Islands to create fishing villages on Newfoundland's coasts. Here were the richest cod schools in the world, but the catch—destined for the world fish market—earned little money with which to buy imported flour, beef, sugar, and tea. For their own consumption, the settlers found it necessary to supplement the local merchants' expensive victuals with hunting, gathering, milking a cow—and gardening, in much the same peculiar manner it had been conducted in the Old World. Unlike the settlers' home districts, however, Newfoundland exists at the very margin of the cultivable world. Compared with Europe, the growing season is a month shorter, and the air colder, windier, foggier, and more likely to deposit frost at any time. The soil is thin and stony and because of its geological immaturity lacks nitrogen, phosphorus, and organic matter. The terrain is usually rough right to the shore. Low rates of evaporation combine with the rains, snows, and mists to leach the soil, making it as acidic as lemonade. The dismaying prospect for crops compelled one survey geologist to wonder in print, "How do you till this land? With a pickax?"

As if the natural conditions were not discouraging enough, there were also cultural and historical obstacles to cultivation. Newfoundland's settlers came from regions where they had been employed tending sheep and cattle or as agricultural laborers. They had kept gardens but were not self-sufficient farmers. Unlike the English countryside, the coasts of Newfoundland had no gentry experimenting and promoting innovations. For centuries, the British government even discouraged cultivation by settlers. Potential mariners for His Majesty's ships, Newfoundland fishermen were kept oriented to the sea. In the settlements, or outports, farming and fishing competed for the family's labor during the peak times of the annual work cycle. Cultivation of the land remained subordinate, even furtive, pursued simply to put food in the larder. It acquired official encouragement or more of the family's attention only when the fishing economy was sacked by world prices or th elusiveness of the cod.

While Newfoundlanders labored unde natural and historical obstacles to raise few vegetables during the summer, the received little praise. Like its Europea ancestor, the Newfoundland lazy bed ga den acquired critics like weeds, each com peting for the most memorable insult t these peasant practices. The primitiv lazy beds, with their folk origins in earl Celtic farms and their association with ig norant poverty, were the compilation o every procedure incompatible with mech anized farming. And the anathema unde which European lazy beds were place followed Newfoundland settlers to th New World. Since the nineteenth centur both provincial and foreign experts hav attacked the lazy beds, their manurin the hand tools, and the labor involved—o lack of it. Most writers, being advocates o progress and modern agriculture, hav concluded that the isolated, illiterat Newfoundland outporters, with their a tention turned to the sea, were abysma truck farmers. For example, the nine teenth-century tourist and author Cap R.B. McRae fumed, "Heaps upon heap of caplin [a small fish] are spread broad cast over the fields for manure, a practic as stupid as it is shortsighted." He contin ued, apocalyptically,

> Nature, careful of her gifts and riche never intended the harvest of life to be use to so vile and wasteful a purpose, withou first undergoing preparations by other nec essary transitions. The farmer, by using fis as a manure, enriches his pastures for a sea son, but impoverishes the ground rapidl while, in revenge for the outrage, vast myr ads of insects, grubs, and caterpillars ar developed from the putrid soil, suddenl overenriched, and which soon spread havo wholesale in fields and gardens on ever side.

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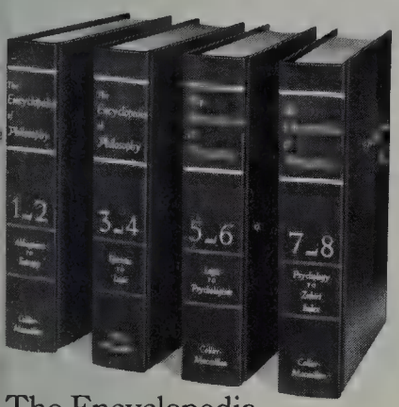

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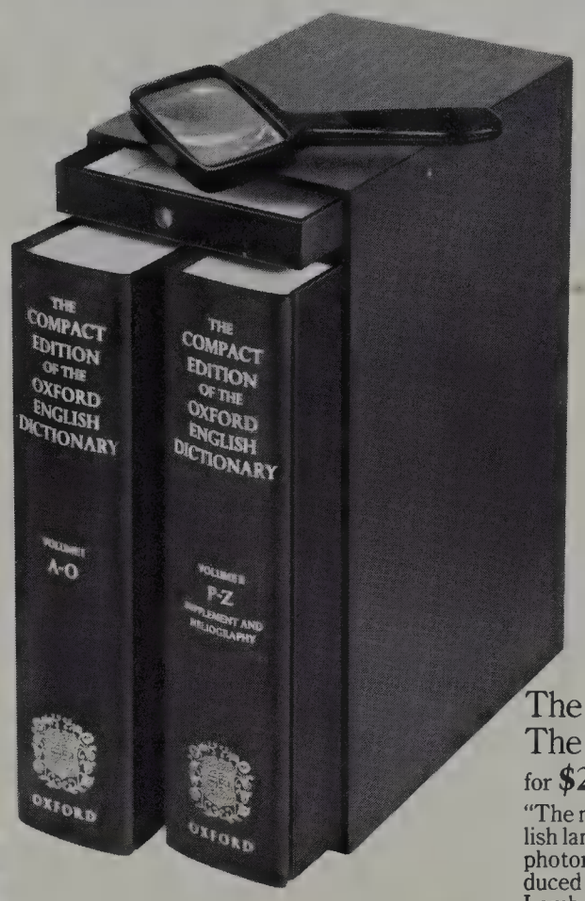
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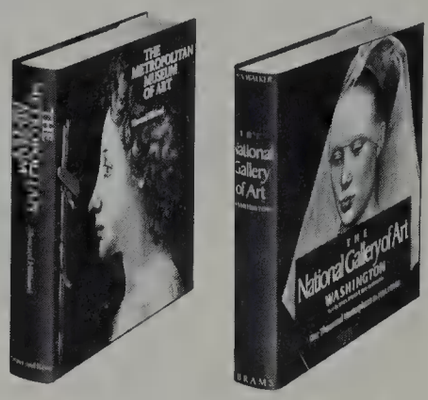

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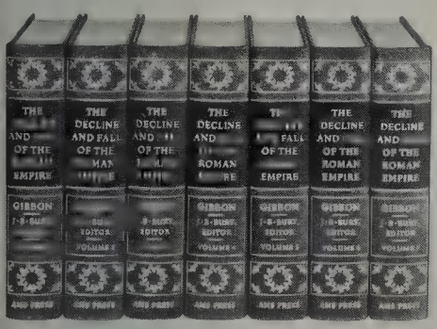

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ers persist in a nearly blanket condemnation. A geographer has written, "Lack of crop rotation, with little fertilizer added save a part of the annual caplin haul, has caused the depletion of fertility instead of the replenishment that might be expected." Even an agricultural specialist and native of the province claimed in exasperated tones, "I'm against lazy beds. It is too much work, it doesn't allow for cultivation, and the nutrients leach out of the beds into the ditches. You can see this in abandoned potato gardens—the ditches have richer vegetation than the beds!" Perhaps inevitably, anthropologists have also picked up this bias. Writing of gardens in Cat Harbour, on the northeast coast, James Faris maintained that deep-water kelp and caplin fertilizers actually depleted the soil.

This, then, is a test for the ecologically minded anthropologist: Can the gardening be that wretched? Are lazy beds a bad Newfie joke? Definitely not. As my wife, Susan, and I discovered on our field trips to Newfoundland, the marginal environmental conditions make gardens risky and the fishing economy makes them merely a sideline occupation, but a gardening tradition has evolved that assures a reliable source of food as well as some critically short nutrients. Lazy bed gardening economizes on labor, cash, and time; it exploits local resources and tools; it improves growing conditions; and it reduces the risk of garden failure presented by unpredictable weather or pests.

An average outport family of four may have a garden of twenty beds, each three by thirty feet and containing about one hundred seeds. To make a bed, kelp is spread over the ground, the seeds are placed on it, and the whole is layered over with soil spaded up from one-foot-wide trenches dug around the bed. The resultant bed is six to ten inches higher than the original land surface, and the trenches are about six inches deep.

Compared to conventional gardening methods, prevalent elsewhere in North America, lazy beds require little of a Newfoundland family's precious summer labor. Planting densely—one plant per square foot—means that there is less work hauling and spreading fertilizer over large areas. The beds can be prepared with only a triangular "trenching spade" and a rake or pitchfork. Their compactness minimizes the building and maintenance of fences. Weeding is reduced—the full green canopy the dense vegetables create by July shuts out the weeds. And because gardeners limit their movements to the trenches around each bed, the ground remains loose.

The lazy beds also compensate for natural hazards. The raised bed protects young plant roots from waterlogging during the overly wet spring. Should the summe turn very dry, as it can in July, gardener may block off trenches to hold water an cover the beds with any available gree rubbish to reduce evaporation. Researc also shows that lazy beds can be warme than the surrounding land. Morning tem peratures on a raised bed, for example can be eight to ten degrees higher. Seed i planted just below the surface of the soil and earlier in the spring than would b possible in a ground-level garden. Thi capitalizes on the sunshine of the lon June days, which encourages early sprout ing—an important advantage where th growing season is so short. In addition beds are often deliberately built on slopin ground, where drainage is improved Slopes that face south receive stronge sunlight, creating a microenvironmen with conditions equal to those found man miles farther south.

Spading soil from the trenches severa times during the growing season return leached nutrients to the beds. Beds an trenches are often alternated annually Newfoundlanders have been criticized fo depleting the soil by intensively plantin the same plot year after year. But how ca a soil be depleted that has so little to begi with? What fertility a garden possesses i put there by the gardener. "Making soil" is the family's annual chore. Formerly rotted stable manure was hauled into th

John T. Omohundro

Near Main Brook, in northern Newfoundland, a fence of spruce slabs protects a potato garden from free-ranging cows.

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garden at winter's end by dog teams or by children with hand barrows. Today, as well as in the past, kelp and rockweed—accumulated in piles on the beach after winter and ice storms—are forked onto the beds up to a depth of six inches.

The seaweed contains colloids that help sweeten the soil. It also replaces potassium and nitrogen that the spring rains leach from the surface. The decay of the kelp takes up nitrogen, which is scarce in the spring, but releases it again during dissolution. Biological research also suggests that rockweed contains a growth hormone and a substance to increase the plant's resistance to frost—likely to occur in the early weeks of emergence. Banked around cabbage stems, the rotting kelp may also confuse the destructive root maggot fly, which chooses where to lay her eggs by smell. (Some gardeners also apply tobacco juice, paprika, or other remedies to discourage the fly.) Finally, the salt in the marine manures actually aids a salt-deficient bog mud, facilitating the nutrient uptake of the plant roots.

"Set 'em in kelp, trench 'em in caplin," the gardeners say. Like kelp, the small silvery caplin fish are a clever garden supplement. By mid-June, when these fish run in the millions onto the shores, outporters scoop net barrelfuls to blanket their gardens. Caplin add calcium and phosphorus to sweeten the soil and to balance the kelp's contribution of potassium. As the whole fish carcass decays, it slowly releases nutrients into the rapidly leached soil. Used in this way, caplin are "time-release capsules," feeding plants when gardeners are busy at other tasks. In some areas, gardens are planted right in the beach sand, so most fertilizer washes up within pitching distance.

But ingenious fertilization techniques are not sufficient to assure a good harvest. Newfoundlanders are compelled by poor soil to cultivate their land intensively. Gardeners bludgeon a crop from a piece of ground. They plant three times as much seed per unit of land as do commercial Newfoundland potato farmers, heaping on three times as much manure and fertilizer. Although their return per pound of seed averages only half of what the commercial farmer gets (6.5 to 15.0 pounds per pound of seed, compared to 17.1 to 28.6 pounds), gardeners usually come out ahead in the yield per acre. For example, in 1982 (not a particularly good year), the thirty gardeners we observed hauled 78 percent more potatoes per acre than the Newfoundland commercial farmers. The comparative loss in efficiency of seed and fertilizer invested in their gardens is more than compensated for by the likelihood of a sufficient crop. A good year means potatoes twice a day for months, plus some to give away or sell. And a bad year will still yield about ten pounds of potatoes per capita per month, from October until June.

In the end, the lazy bed garden costs the outporters little for their vegetables, and it saves them much. An average garden consumes about eight person-days of labor—labor that has little cash value because the time is plucked from the gaps in the day's major chores of fishing or wagework. During the idle days of early spring, for example, the dwindling supply of potatoes for seed is eked out by cutting them into egg-size pieces, each with a sprouted eye. Commercial farmers do not do this, both because of the labor and the risk of plant disease. Individual garden work is lightened because the labor is shared by groups of workers—families or extended families—who entertain themselves while they work.

Until the 1950s, no cash was spent in gardening, but then, little cash was available. Nowadays, fertilizer or seed may be purchased at a cost of $46–$78 per gar-

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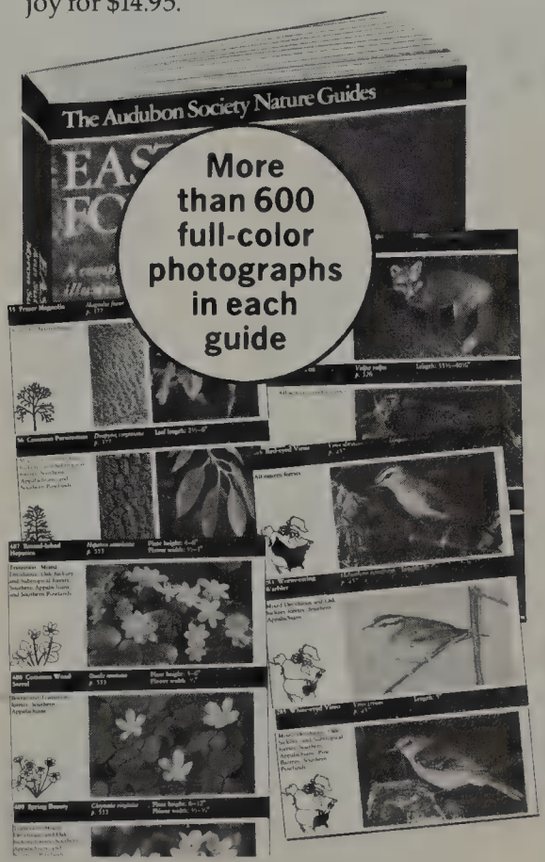

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den—less than one and one-half days' wages at a local fish plant. The return of more than thirteen pounds of potatoes per dollar invested compares favorably with the commercial farmer's return of fifteen pounds per dollar (not counting the capital investment involved in mechanized farming). The average garden's yield would cost from $100 to $200 in the shops in the fall; stored in semi-subterranean root cellars, the crop more than doubles in value by spring, if the merchant's vegetable prices are taken as a guide. Newfoundland's lazy beds are thus a balanced investment of land, labor, time, and materials, in which people exploit limited resources to overcome prodigious obstacles.

How did the Newfoundlanders arrive at this system? Do the gardeners understand the value of what they're doing and why it works? Probably no individual is aware of the whole picture, and most of the gardeners cling to a few oddball notions, such as the belief that lightning wilts potato vines. But collectively, a community of gardeners knows most of what is reported here. And because gardening is both competitive (it confers prestige to cultivate a bountiful garden) and highly sociable (people trade labor and seed and endless talk about gardens), the collective wisdo is constantly redistributed. The mech nism for the evolution of Newfoundlar gardening from its European origins is th accumulation and success of small exper ments, serendipitous discoveries, and in perfect imitations over the three hundre years of settlement.

Never widely acknowledged, lazy be gardening was nearly forgotten whe Newfoundland joined Canada in 194 Unemployment compensation, retiremer benefits, and welfare checks became si nificant parts of family income. The fis ing and logging industries were revitalize for a time, and they paid well. Roads b gan to connect isolated communities regular groceries, to commuting wag work, health care, and other convenienc of civilization. Some isolated communitie were simply evacuated. Hoping to catc up with twentieth-century Canada, New foundlanders consequently abandone home food production. "Gardens, goat and berry picking" were stigmatized a remnants of the depression years. Canne goods, and houses modeled after those Toronto suburbs, became fashionabl Pasture fences fell into disrepair, an eight-foot-high weed forests replaced th trim rows of potato and cabbage plants

By 1965, household food productio had fallen to an all-time low, with less tha half the community growing anythin Gardens were small and contained fewe crops. Bad years "at the fish" or "in th woods," rather than prompting a retreat self-sufficiency, encouraged a mass ex dus of young men and women to the fa tories, forests, and oil fields of mainlan Canada. The outports lost many appre tice gardeners and strong workers. Th survival traditions appeared to be dyin with the older generation.

But by the 1970s, outport residents rea ized that rapid progress toward the grea Canadian mean would be much slowe than anticipated, if it occurred at all. In flation had skyrocketed, and workers lai off in Toronto and Alberta returned t their families. Only ten years after oil an electricity had made hot-air furnaces stan dard, they were being replaced with al night woodburners. "Worst we ever done give up the cows, the gardens," one ga dener told us. "We gave 'em up becaus we thought times was getting better. Bu they weren't. People are going to have t go back to the ground again."

As Newfoundlanders moderated thei expectations, gardening's decline levele off in the 1970s and even made a slight re covery. On the island's Great Norther Peninsula, where we have concentrate our fieldwork, about half the families ar

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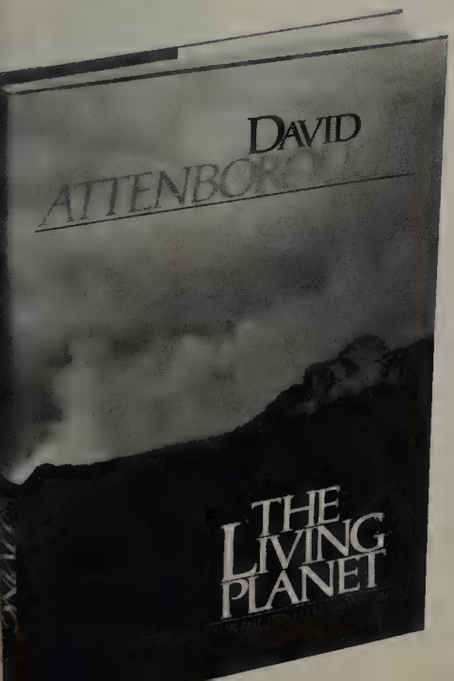

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OIL AND WATER

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WILLIAM H. MACLEISH
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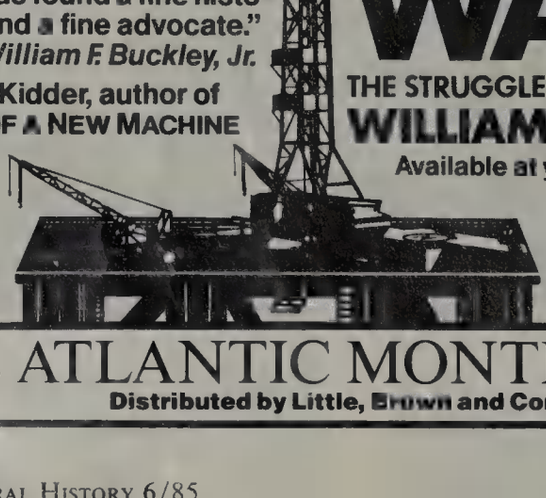

THE ATLANTIC MONTHLY PRESS
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now spading a garden in May. Familie are smaller, tastes have changed, and s gardens are accordingly smaller and mor experimental. A gardener's prestige sti depends upon the quality and quantity o the potatoes, but extra merit is earned no from lettuce, strawberries, or onions. In spired by mainland seed catalogs, the opt mist nurtures—and invariably loses—a tomato or a pumpkin.

Today, the revived gardening traditio continues to evolve, sometimes aided b government funds. Two innovations in re cent years are greenhouses and communa gardens. The opening of the highway ont the peninsula in the 1960s increased th ease of reaching plots distant from the ou ports. Since the improvement of the road involved a great deal of earth moving an the opening of gravel pits, the use of so turned up along the highway is extensive Gravel pits, easily tilled and functionin as solar collectors, have become popula garden locations. And the roadside bank of drained peat or sandy soil, often slante to the sun, are easily accessible. Such roadside gardens were widespread i Devon and Dorset, but the Newfoundlan practice appears to be an independent in vention under similar economic and geo graphic circumstances.

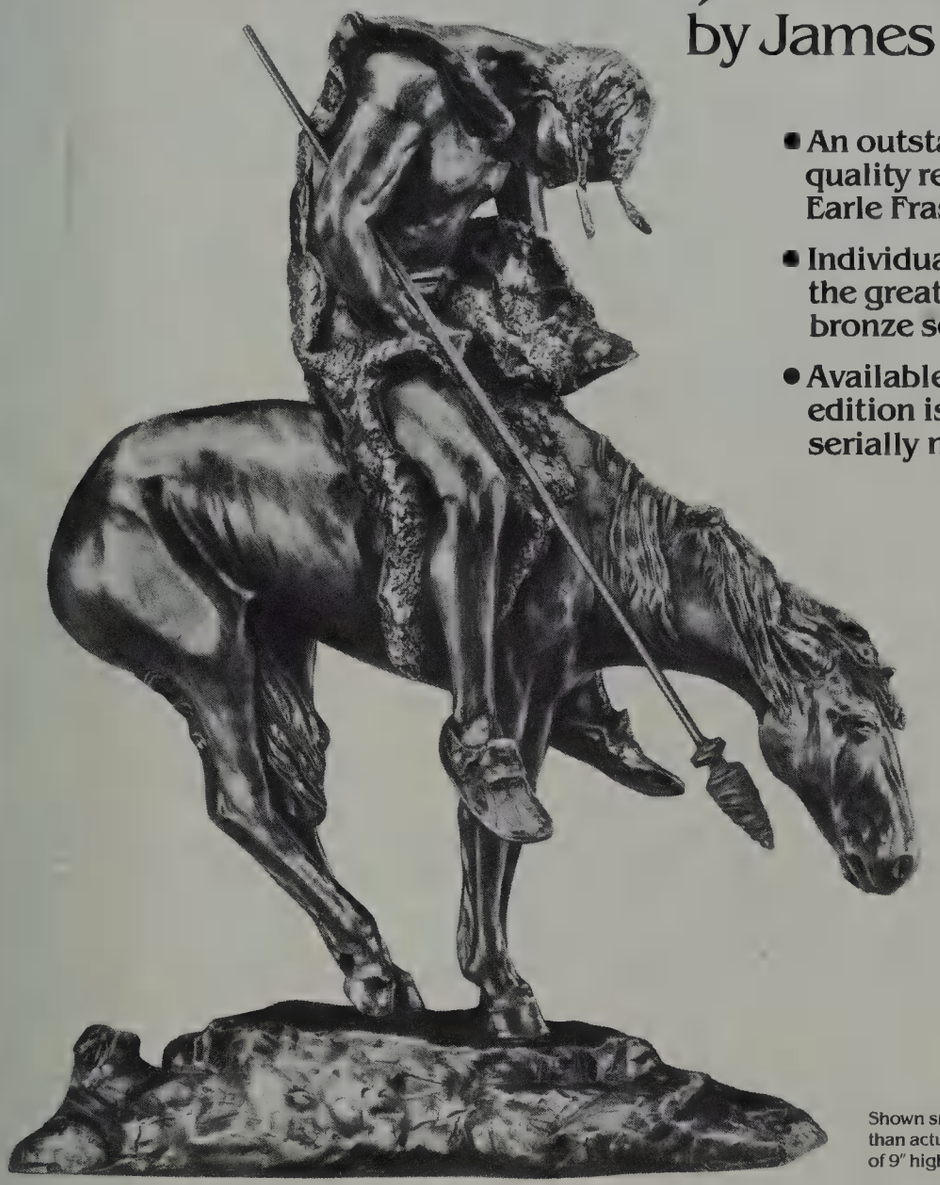
Knowledge of Newfoundlanders' ga dening techniques could be of practica benefit to readers who garden in similar cool, wet, and infertile regions. Settler once raised vegetables in lazy bed garden in the Adirondack Mountains, on Sain Lawrence River islands, and on the rock coast of Maine. But commercial food be came available year-round in those area many years ago, and the tradition dwin dled before it was fully recorded and ap preciated. In Newfoundland, by contras the centuries-old gardening tradition ha been preserved because until recentl commercial foods were scarce and expen sive. Outport gardens are anachronism but instructive ones. The example the provide expands our agricultural option increasing our flexibility today to fee ourselves in a wide variety of enviro ments. If nothing else, the realization tha Newfoundland lazy beds are clever in stead of ridiculous should give pause t those whose world view is stamped on with the image of commercial energ intensive agriculture.

John T. Omohundro is an associate pro fessor of anthropology at the State Un versity College of Arts and Sciences Potsdam, New York. Since 1979, he an his wife, Susan, have visited the Island Newfoundland each year to preserve th local lore about subsistence activities.

NE

"The End of the Trail"

by James Earle Fraser



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Croatan National Forest, North Carolina

by Robert H. Mohlenbrock

On casual inspection, Croatan National Forest is unalluring. This small pineland on North Carolina's coastal plain contains large expanses of boglike habitat with scrubby vegetation. But in these areas, where the soil is generally too poor to support trees, grows the widest selection of carnivorous plants found in any U.S. national forest.

The alternate life style of carnivorous plants arouses almost everyone's curiosity. It is not true, as botanist G.E. Rumphius reported from Malaysia in 1783 (and as *American Weekly* magazine told its readers in the 1920s), that there are vicious plants in Madagascar, the Malay Archipelago, and the Philippines capable of killing and even swallowing humans. But there are some 350 different kinds of flowering plants in the world that trap and digest insects and other small animals. Since their victims include small amphibians and reptiles and an assortment of invertebrates, they are referred to as carnivorous, rather than insectivorous, plants.

Botanists recognize forty-five species of carnivorous plants in the United States, and at least eleven of these live in Croatan. The Venus's flytrap is the most famous, probably because the movements of its inch-long traps are easily observed. The plants' traps are twin-lobed leaves that are hinged between the lobes. Each lobe is rimmed with narrow, stiff teeth and bears three slender, supersensitive hairs on its inner surface. If two of these hairs are touched within a period of about thirty seconds, the two lobes of the trap close, and the teeth along their edges become intermeshed.

The requirement that two hairs need to be touched to trigger the trap is a way the plant saves energy. If an inanimate, and therefore probably nonnutritious, object brushes a hair by chance, the trap remains open. But an insect crawling on the trap is apt to brush against two of the hairs sooner or later, triggering the trap. At first, the teeth along the edges do not intermesh completely, allowing very tiny insects, which have little food value, to escape. If there is no substantial prey, the trap then reopens, but if the insect is large and continues to wriggle, the trap closes completely. Once entombed, the insect is digested in twenty-four to thirty-six hours by enzymes. Afterwards, the trap reopens and lies in readiness for its next meal.

Venus's flytrap and other carnivorous plants possess chlorophyll and thus are capable of manufacturing their own nutrients; their carnivory is an adaptation to nutrient-poor environments. In Croatan National Forest, the habitat in which they grow is known as pocosin, from an Algonquian expression that means "swamp on a hill." Pocosins are flat, slightly elevated areas with poor drainage, ranging up to several hundred acres in extent. They seldom flood, but small pools may appear during the winter.

The pocosin's ooze of black soil looks rich but is highly acidic. Soil acids combine with bases to create water-soluble salts; in this form, many essential soil minerals are washed away by the frequent drenching rains. The soil gets its deceptively rich appearance from carbon—charcoal left by spring fires. Spring is a dry season in Croatan, and plant debris from the previous growing season dries out rapidly. Fires commonly break out and remove the litter, inhibiting the growth of shrubs and aiding the carnivorous plants, which thrive in sunlight. When natural fires fail to suppress shrubs, U.S. Forest Service personnel sometimes supervise controlled burning.

In addition to the Venus's flytrap, ten other species of carnivorous plants are

Debbie Rymal Folkerts

On sundews exposed to full sunlight, new growth is red.
Opposite: A yellow trumpet pitcher plant.

Edward Schell

found in the Croatan pocosins: two pitcher plants, two sundews, a butterwort, and five bladderworts. A pitcher plant has one or more tubular or funnel-shaped leaves with an opening at the upper end known as the mouth. Projecting upward beyond the mouth is a lid, or hood. Early naturalists, including Linnaeus, thought that the lid was hinged and could be opened or closed by the plant to regulate the amount of water that accumulated inside the pitcher. Actually, the position of the lid is fixed. The eighteenth-century naturalist Mark Catesby speculated that the pitchers were used as hiding places for frogs and other small animals. It wasn't until 1817 that a physician, Dr. James Macbride, realized that the pitchers were able to attract flies with a sweet secretion. He noted that once it has fallen into the bottom of a pitcher, a fly cannot escape because downward-pointing hairs line the leaf's inner walls.

Like flowers, most pitchers are brightly colored to attract nectar-seeking insects. The thick rim, which secretes nectar, is colorful, shiny—and slippery. The visiting insect eventually slips on the rim surface and falls into the bottom of the pitcher, which contains a mixture of rainwater and digestive enzymes. A pile of undigested insect skeletons eventually accumulates within the plant.

Two of the 120 kinds of sundews in the world live in very damp areas in Croatan. Sundews are perky-looking little plants whose crowded rosettes of leaves form at ground level. All the leaves secrete droplets of a colorless, sticky liquid at the tips of countless slender hairs. Insects that venture on them are unable to pull free and eventually perish. Sundew leaves also have enzyme-producing glands, mostly along the center of each leaf, and an insect caught in this area is engulfed quickly. Should an insect land near the edge of the leaf, the hairs will bend inward, transporting the captive to where the enzymes are concentrated.

The blue butterwort, or *Pinguicula*, is another kind of "flypaper" plant. Although it is not related to the sundews, the butterwort also has all its leaves in a basal cluster. A sticky substance covers the upper surface of these leaves, but not the tips of hairs, as in the sundews. If an insect gets mired down on one of the gummy leaves, the leaf curls slightly so that the surface becomes concave, forming a basin in which the digestive enzymes accumulate.

Numerous depressions with shallow standing water dot Croatan, and most of them support still another group of carnivorous plants, known as bladderworts. Five kinds of bladderworts grow in or along the margins of these depressions, their intricately branched stems floating in the water. All along the stems are transparent, air-filled bladders about one-sixth of an inch long. Each bladder has a small mouth at one end, but the mouth is normally closed by a trap door. When a tiny water animal swims into contact with one of two trigger hairs at the entrance to the mouth, the trap door suddenly swings inward, and the inrushing water sweeps the animal inside. The water filling the bladder forces the trap door closed, and the prey is condemned to digestion by enzymes secreted within the chamber. After several hours, the water is forced out of the bladder, and the trap is set again.

Charles Darwin, one of the first scientists to consider the biology of carnivorous plants, was aware that pitcher plants, sundews, and others of their kind were adapted to poor soils. But what nutrients are missing from lands like the pocosins? Because plant growth is often inhibited by lack of assimilable nitrogen, scientists had long assumed that plants developed carnivory specifically to supplement their nitrogen sources. However, botanists Lionel Eleuterius and S.B. Jones, Jr., working with carnivorous plants in Mississippi, found that the soils that supported these plants were not deficient in nitrogen, phosphorus, or potassium. When fertilizers that contained these elements were applied to the soil, the carnivorous plants actually did poorly. Recently, zoologist George Folkerts suggested that a shortage of trace elements—particularly molybdenum, which is scarce in acidic soils—may have been the key to the development of carnivorous plants. The Fish and Wildlife Service has been studying pocosins for their value as a wetland resource. The results of their soil analyses may shed further light on the relationship between carnivorous plants and their characteristic habitat.

"This Land" highlights the biological phenomena of the 153 U.S. national forests. Robert H. Mohlenbrock is professor of botany at Southern Illinois University at Carbondale.

Croatan National Forest

Joe LeMonnier

For visitor information, contact:
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A young frog falls victim to Venus's flytrap.

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Marine pondweeds are flowering plants that are usually submerged. When they bloom, their pollen is carried not by the birds or the bees but by water.

Entheos

Noodles on the Tide

Why is water-borne pollen so long and stringy?

by Paul Alan Cox

In 1827, Scottish botanist Robert Brown placed some pollen grains in water for study under his microscope. His initial excitement upon finding the particles "very evidently in motion" was soon dampened when subsequent control experiments revealed that small particles of wood, metal, and stone moved just as actively under the same conditions. Brown, to his disappointment, had not discovered the essential force animating all life but had demonstrated that all small particles, regardless of their composition, exhibit random motion in water.

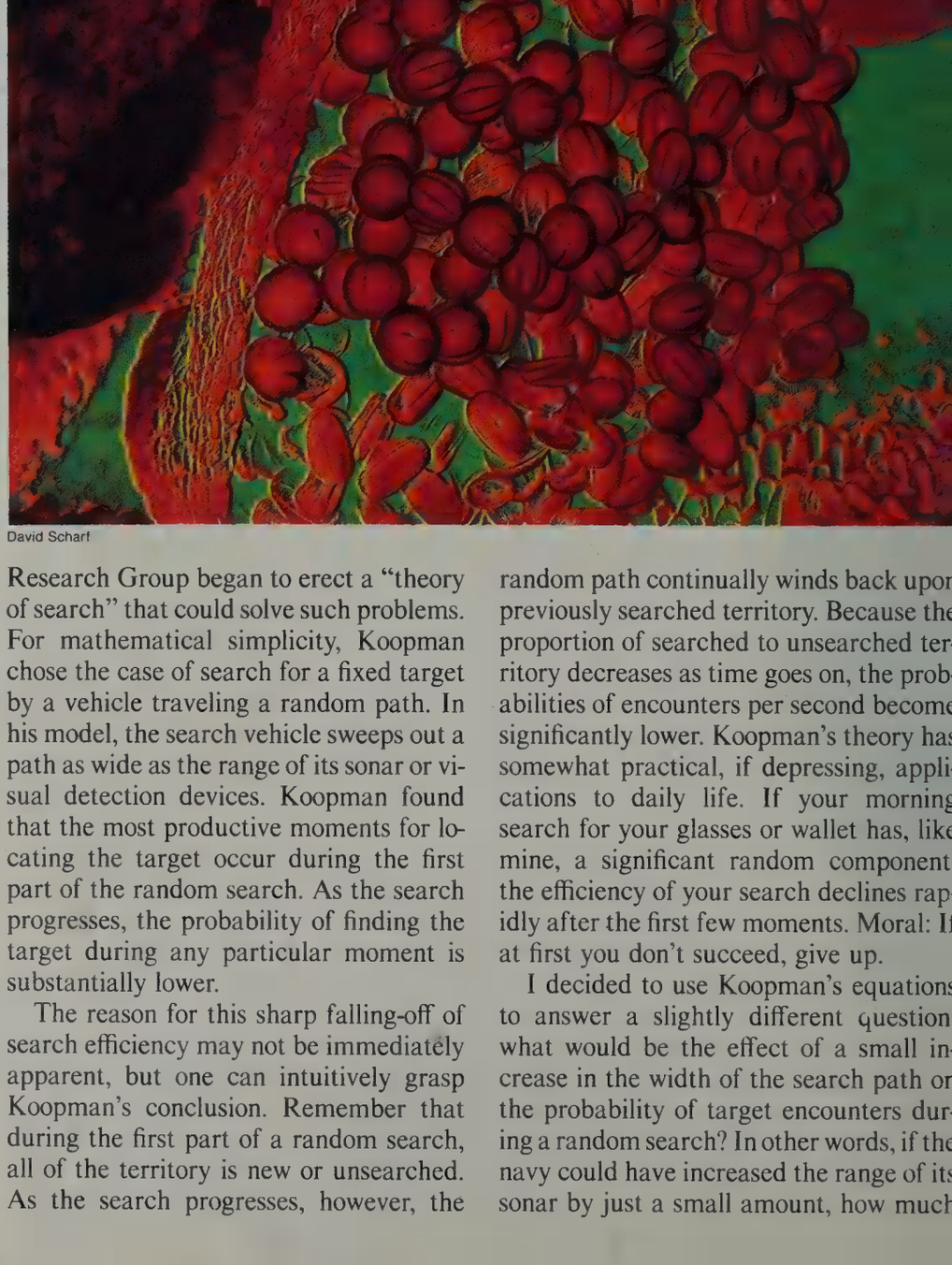
The observations were published as a minor curiosity and largely ignored until the concept they embodied was resurrected by modern physics. Einstein's mathematical exploration of the forces observed by Brown led to the acceptance of the idea that atoms and molecules were real entities, not just theoretical concepts useful in explaining the physical world. Later, Jean Perrin used Brownian motion to obtain a value for the Avogadro number, a feat for which he was awarded the Nobel Prize in 1929.

While botany has not become the main beneficiary of botanist Brown's experiments with pollen, the mathematics of random motion inspired by his observations now provides insights into the system that originally attracted his attention—the movement of pollen grains and fungal spores in water. Among other things, his insight has helped explain why some aquatic flowering plants have such large pollen grains and why aquatic fungi have such large spores.

In most aquatic flowering plants—such as watercress and lotus—pollination takes place the same way it does on land. Wind or insects, birds or animals, carry pollen from flower to flower. In some species, however, pollen is carried on or in the water. Within this group, the sizes and shapes of pollen grains are strikingly similar. They are either very long and threadlike or packaged in elongated conveyances. And compared to land plant pollen grains, which are so tiny that they cannot be seen without a microscope, water-borne pollen is huge.

A typical example is *Thalassadendron,*

Garry T. Cole



David Scharf

a sea grass that grows along the coasts of the Red Sea, the western Indian Ocean, and Australia. Its pollen grains are nearly one-quarter of an inch long—more than 120 times the size of land pollen—and look for all the world like thin spaghetti noodles floating in the tide. Pollen grains of the Australian sea nymph, *Amphibolis*, are not only long and slender but also have hooked ends, which catch on to one another and form ropelike chains that float through the water.

Perhaps even more unusual is the pollen of *Halophila* (the sea wrack), a small sea grass common in shallow water off the coasts of many islands in the South Pacific. In Samoa, a diver with a mask and snorkel can easily observe sea wrack plants well inside the reef at wading depth. Long lines of evenly spaced small plants with oval-shaped leaves seem to emerge directly from the sandy bottom. A tug on a portion of this line reveals, however, that what appears to be a group of separate plants is in fact one plant, connected by hidden horizontal runners called rhizomes. A single genetic individual can occupy several hundred linear feet of the white surface sand.

The sea wrack rarely blooms, but when it does, the male plants produce pollen that is packaged and dispersed in a remarkable fashion. Most flowers produce pollen grains in groups of four, called tetrads. As they mature, the tetrads divide into four separate grains, which are then individually dispersed. Sea wrack pollen grains, however, remain fused in tetrads, and these clusters are dispersed within a very long mucilaginous tube that floats through the water.

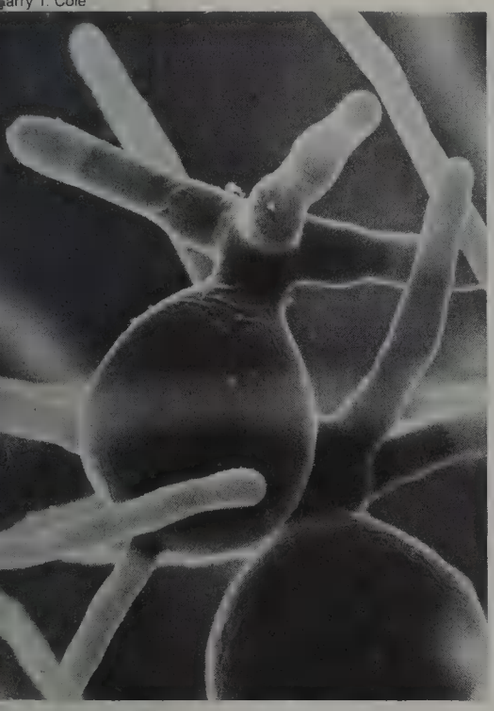
Is there a functional explanation for such odd pollen forms or do they merely represent interesting but insignificant quirks of nature? I began to suspect that there was an adaptive explanation for the structure of sea grass pollens when, during the course of another study, I stumbled upon a series of papers on antisubmarine warfare. During World War II, the U.S. Navy asked Bernard Koopman, a mathematician at Columbia University, to help devise ways to locate Nazi U-boats. Koopman and his colleagues in the Operations Research Group began to erect a "theory of search" that could solve such problems. For mathematical simplicity, Koopman chose the case of search for a fixed target by a vehicle traveling a random path. In his model, the search vehicle sweeps out a path as wide as the range of its sonar or visual detection devices. Koopman found that the most productive moments for locating the target occur during the first part of the random search. As the search progresses, the probability of finding the target during any particular moment is substantially lower.

The reason for this sharp falling-off of search efficiency may not be immediately apparent, but one can intuitively grasp Koopman's conclusion. Remember that during the first part of a random search, all of the territory is new or unsearched. As the search progresses, however, the random path continually winds back upon previously searched territory. Because the proportion of searched to unsearched territory decreases as time goes on, the probabilities of encounters per second become significantly lower. Koopman's theory has somewhat practical, if depressing, applications to daily life. If your morning search for your glasses or wallet has, like mine, a significant random component, the efficiency of your search declines rapidly after the first few moments. Moral: If at first you don't succeed, give up.

I decided to use Koopman's equations to answer a slightly different question: what would be the effect of a small increase in the width of the search path on the probability of target encounters during a random search? In other words, if the navy could have increased the range of its sonar by just a small amount, how much

Flowering plants that bloom on land produce pollen that is spherical and microscopically small (facing page, bottom). Water-borne pollen, however, is often long and threadlike (this page, right) and large enough to be visible to the naked eye. Similarly, fungi that grow in water commonly produce large and fantastically shaped spores (facing page, top, and this page, left). Mathematical analysis predicts that large size and complex shape increase search efficiency.

Barry T. Cole



C.A. McConchie

would it have increased the chances of locating a stationary target in a random search? To my surprise, even a small increase in the width of the path results in a vast increase in the likelihood of encountering a target. The biological implications of this observation are intriguing. Anything that increases the average width of the path swept by an aquatic pollen grain should greatly increase the probability that it will hit its "target"—the female stigma of a plant—during a random search. On the basis of search efficiencies alone, elongated shapes or large search vehicles should help aquatic pollen grains find the stigma.

Imagine, for example, the width of the path swept by the search vehicles of water nymph (*Najas*) pollen. In these freshwater plants, the pollen is small and round but has the unusual habit of germinating before it leaves the anther. (When a pollen grain germinates, it grows a pollen tube, the structure through which a nucleus will pass to fertilize an egg. Most pollen grains, terrestrial or aquatic, germinate *after* contact with a stigma.) Thus the water nymph's pollen grain with its long tube becomes the male search vehicle, sweeping an average path equal in width to the pollen grain diameter plus the length of its pollen tube. Early pollen tube formation also occurs in the marine turtlegrass *Thalassia* and in the water starwort *Callitriche*, found in shallow ponds in California. Similarly wide search paths are also obtained by the flowering hornwort *Ceratophyllum*, which releases entire pollen-bearing anthers equipped with floats that carry them from underwater to the surface. The anthers are about thirty-three times larger than the average diameter of airborne pollen.

Perhaps the most startling and beautiful means of improving search efficiency occur in the freshwater eel grass *Vallisneria* and in the unrelated marine flatweed *Enhalus*. Found in quiet freshwater ponds and streams throughout the world, eel grass is also popular as an aquarium plant. It grows submerged and has long, straplike leaves up to six feet long, depending on the water depth. The leaves are produced from a central tuft anchored in the pond mud, and the plant spreads by runners.

Flatweed grows in shallow water off the coast of Australia and various islands in the South Pacific. The plants have long, belt-shaped green leaves up to about two feet long. During flowering, the water surface above the plants seems littered with white confetti; actually, the confetti are tiny male flatweed flowers. In both flatweed and eel grass, the entire male flower is released from beneath the water surface, floats to the top, and in essence becomes the search vehicle. After the male eel grass flower reaches the surface, three tiny stamens become erect and function as a sail. The female flower floats slightly below the surface level, creating a small depression into which the male flowers tumble. In effect, the target is the depression created by surface tension.

In flatweed, the target is the floating cluster of long petals borne by the female flower. The female flower is firmly anchored, however, by a long stalk attached to the base of the plant and rooted into the sandy bottom. Any male flower falling within the petals is completely enveloped as the tide rises, and pollination occurs.

Perhaps the reason that such unusual search vehicles are not found in plants whose pollen is aerially dispersed is the risk of desiccation. The high surface-to-volume ratios of elongated pollen grains might result in rapid, irreversible water loss if the grains were transported through air rather than water. In any case, wind- or animal-dispersed pollen grains are not likely to follow random trajectories. In water, however, the combined actions of wind and orbital wave motion probably introduce enough randomness into the

search paths of pollen to satisfy Koopman's random-search theory.

If these structures have evolved in aquatic flowering plants because they increase search efficiency, one would expect that unrelated organisms with similar search problems would also have structures that are alike. Called convergent evolution, the development of similarities in unrelated organisms is frequently good evidence of adaptation. Many flowering plants in African deserts, for example, are superficially very much like the American cactus plant. Even though they are evolutionarily unrelated, both types of plants produce fleshy, round green stems covered with spines. Their resemblance suggests that a succulent cylindrical form, armored with spines, is an adaptation to desert conditions since it occurs in completely unrelated desert plants. Thus if a group of organisms unrelated to aquatic flowering plants but possessing similar search problems were found to have similar dispersal forms, this would be strong evidence that elongated pollen shapes are indeed adaptive.

Accordingly, I examined spores in the Hyphomycetes, a group of terrestrial and aquatic fungi. The aquatic members have a search problem somewhat analogous to that faced by flowering plants with water-mediated pollination systems. The spore of an aquatic fungus must travel through the water to find, not a stigma, but a host of living or decaying organic matter in which it can germinate. In both cases, the search is for a relatively fixed target. Have the fungi and the flowers evolved along similar lines?

Indeed, large, unusually shaped spores are common among aquatic fungi. In aquatic hyphomycetes, mycelia—threadlike fungal tubes—branch inside of the host tissue, and organs from which the spores are liberated project into the water. The spores of these aquatic organisms are either long, threadlike, and S-shaped or they are tetraradiate (four-pronged) structures, with long arms branching from a single point. The tetraradiate spores of *Actinospora* are nearly thirty-eight times the mean diameter of their terrestrial counterparts.

Even stronger evidence of evolution toward efficient search is provided by a single species of aquatic fungus that produces both aerial- and water-dispersed spores of different sizes or shapes. John Webster, of the University of Exeter, has described just such a situation in species of the genus *Entomophthora,* in which the spores are egg shaped if dispersed aerially but tetraradiate if they are dispersed underwater.

Like aquatic pollen that sprouts prematurely, some fungal spores germinate before they encounter their hosts. In these fungi, the search vehicle is the spore plus one or more long germ tubes. Other structures also widen the search vehicle. The marine fungus *Nia vibrissa* produces long appendages on its spores before dispersal. Just as solar panels slowly unfold from a satellite once it reaches its orbital position, so the gelatinous membranes of spores of the fungus *Pleospora lignicola* expand upon contact with water, forming three blunt arms that greatly increase its effective search width.

These unusual shapes and sizes may serve other functions as well. Filamentous or tetraradiate shapes may—like grapnels or bolos—more easily anchor to their targets once contact is made. Some botanists have suggested that elongate sea grass pollen may wrap around the stigmas, while the arms of tetraradiate fungal spores anchor them to their host's tissue. Experiments indicate that tetraradiate fungal spores are trapped more frequently by underwater surfaces and air bubbles than are spherical spores. These theories pertain more to aquatic spore shape than to size; a combination of search and "anchoring" hypotheses may be required to explain the structure of aquatic spores.

Just as physicists and mathematicians have learned from Brown's observations of pollen grains in water, so botanists stand to learn much about pollen and spores by considering the mathematics of random motion and random search. It seems fitting that the work of botanist Robert Brown—which began with pollen grains and spores and spawned such great advances in physics and mathematics—should now come full circle. □

Tiny male eel grass flowers sail toward the much larger female. Floating slightly below the surface, the female blossom creates a small depression in the water, into which the male flowers tumble. In effect, the whole male flower functions as a search vehicle carrying a cargo of pollen.

S.R. Morris: Oxford Scientific Films

In November 1911, the schooner James T. Maxwell, Jr., *was abandoned fifty-eight miles east of Cape Charles, Virginia. A Coast Guard ship tracked down the hazardous derelict and towed it to port.*
Brown Brothers Photo, Collection of W.J. Lewis Parker

Derelicts and Drifters

Old abandoned sailing ships and new satellite-tracked buoys tell us where some ocean currents came from and where they're going

by Philip L. Richardson

As a child growing up in a small coastal town in northern California, I used to daydream about sunken wooden ships. I pictured them drifting endlessly through the water, each at a different depth. The ocean was layered, I thought, with these trapped, abandoned vessels. Years later, when I had become a physical oceanographer and moved to the Atlantic Coast, I learned that abandoned wooden sailing ships had indeed drifted in the ocean—but on its surface and not forever. In the late 1800s, sightings of these derelicts provided the first information on the paths of surface currents, particularly of the Gulf Stream, in the North Atlantic. For eight years I had been studying the Gulf Stream, using freely drifting buoys tracked by satellite, and I thought I was the first to assemble a sizable body of information on current trajectories in the North Atlantic. I was wrong. The earlier information, which had been forgotten in the last eighty to one hundred years, was also extensive and quite accurate.

The nineteenth-century derelicts that provided information on surface currents were wooden-hulled ships; those that stayed afloat the longest—for more than the average thirty days—were often schooners carrying cargoes of lumber. From the point of view of a ship's captain, any drifting derelict was a formidable hazard. A collision with such an object at night or in a fog could damage or sink a ship. Toward the end of the last century, the Atlantic Ocean was strewn with numerous abandoned schooners and barks in various stages of disintegration.

In December 1883, the U.S. Navy Hydrographic Office, a branch of the Bureau of Navigation of the Navy Department, began to publish monthly pilot charts for the North Atlantic that showed the positions of the abandoned ships—identified by name—and of other drifting debris. The charts were issued free to navigators in return for their reports of recent navigational and weather information. The pilot charts were successful because a large number of observers contributed information to them each month and because they were distributed rapidly to ships' captains.

In the late 1800s, more than 1,600 derelicts were sighted, and reports were collected from nearly 3,000 voluntary observers—mariners who crossed the North Atlantic and who patrolled its waters. These sightings provided information on the bifurcation of the Gulf Stream near the Grand Banks of Newfoundland and evidence of the variability of ocean currents. They also documented a tragic loss of life. Toward the end of the nineteenth century, 12,000 lives and 2,200 vessels were lost worldwide at sea each year. Every severe ocean storm left new derelicts in its path and added new names to the long list of vessels that left port but were never heard from again.

Most of the reported derelicts were found in the Gulf Stream off the U.S. coast. Because of the hazard they represented to other ships, they were sought actively, initially by U.S. naval vessels, later by revenue cutters—armed government ships used primarily to prevent smuggling. When sighted, the derelicts were towed into port or set on fire while still at sea. During 1887–93, forty-one derelicts were towed ashore and another seventy-six were set on fire. One was destroyed by torpedoes and ramming. Others continued to drift until they broke apart or became so waterlogged and encrusted with barnacles that they sank on their own.

This is a typical pilot chart report, written in July 1889:

Notable Derelicts in the North Atlantic
Of the many wrecks afloat this month in the North Atlantic Ocean, none has as interesting a history as the Italian bark "Vincenzo Perrotta." Abandoned September 18, 1887, this vessel has been represented graphically on every edition of the Pilot Chart published since that time. Her wonderful drift began in about latitude 36°N, longitude 54°W [south of Newfoundland, east of Cape Hatteras]; and on April 4, 1889, when last reported, she was about 60 miles north of Watling's island, in the Bahamas. She has thus made good a distance of about 1,400 miles in a general SW. by W. direction, in 1 year, 6 months, and 16 days. She has been reported 27 times in all, and when last seen had mizzenmast and about 10 feet of mainmast standing, foremast gone, end of jibboom broken off and port anchor on bow.

In addition to the derelicts, other debris was reported drifting in the North Atlantic. In December 1887, a large raft of logs broke apart while being towed from Nova Scotia to New York by the steamship *Miranda*. The raft, which weighed 11,000 tons and drew twenty feet of water, consisted of 27,000 tree trunks bound with chains into the shape of a cigar. The logs were spruce pilings meant for the construction of docks and the foundations of large buildings. On December 18, the towing steamship *Miranda* encountered a severe storm. Her fifteen-inch towing hawser parted and the log raft went adrift in the track of commercial navigation. Although a search was made for the raft within a week of her disappearance, only remnant logs were found scattered over a wide area, about 140 miles southeast of Cape Cod. No ship was reported

Sailors leave a derelict ship after completing preparations to blow it up. If not burned, towed, or otherwise removed, such vessels often drifted for months, presenting a danger to passing ships. Derelict ships became a rarity as iron and steel replaced wood as a shipbuilding material.

The Metropolitan Magazine (September 1911), The New York Public Library

lost because of the incident, but the German bark *Bremen* was in the area for five days and had her sheathing torn and her rudder damaged. This log raft was one of only two of its kind that appeared on the east coast; an earlier one had arrived safely in New York from Nova Scotia. Schooner owners and captains, whose livelihood was threatened by the use of such rafts, were delighted that they proved impractical.

Many derelicts remained afloat for more than half a year and were reported often enough to provide evidence of long and interesting ocean trajectories. Six drifted longer than a year—the schooner *Fannie E. Wolston* drifted for 1,100 days; the schooner *Wyer G. Sargent*, 615 days; the bark *Telemach*, 551 days; the bark *Vincenzo Perrotta*, 536 days; the schooner *Ethel M. Davis*, 370 days; and the schooner *James B. Drury*, 367 days. These abandoned ships traversed from 1,700 to 9,000 miles.

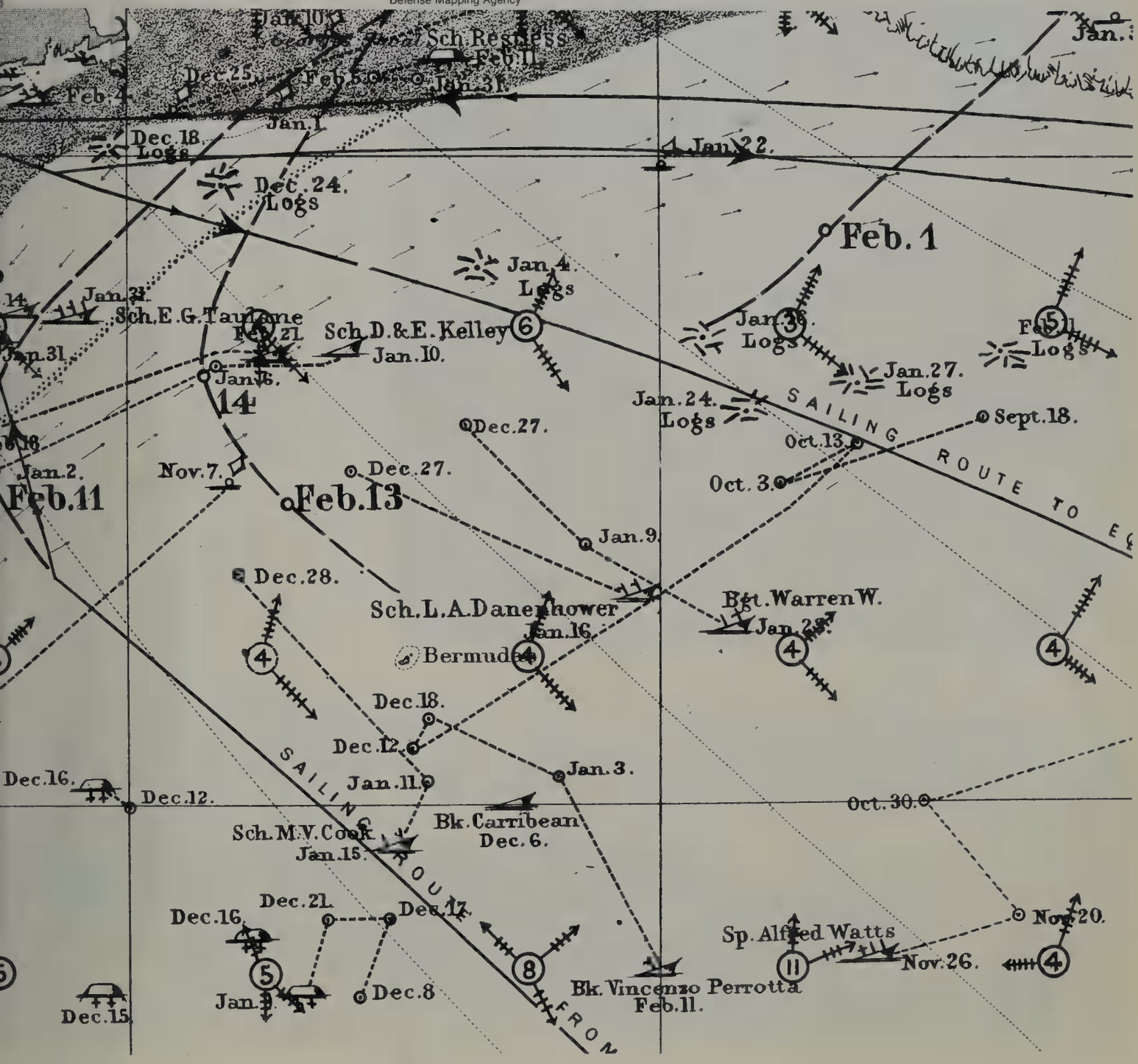
Although the paths of these long-lived derelicts differed markedly in detail, patterns of drift can be detected. Several ships moved eastward in the Gulf Stream until they reached 50°W (south of the Grand Banks of Newfoundland), where their paths diverged. Some continued eastward and crossed the Atlantic in an average of ten months, others drifted southward. Two made tight turns and drifted westward just south of the Gulf Stream. The *Wolston*, which drifted for three years, first floated south to 25°N, then westward in the North Equatorial Current to the Bahamas, and finally northeastward into the Gulf Stream again, crossing its earlier path. Two derelicts drifted erratically but in a generally southwestward direction through the Sargasso Sea and grounded on the Bahama Islands. Most derelicts looped as they drifted. The *Sargent* and the *Wolston* made large, 300-mile loops (southeast of the Grand Banks) within a period of ten months. Several other derelicts made frequent, smaller-scale loops.

Derelicts that first appeared near the coast between Long Island and Cape Hatteras usually drifted southwestward, following the inshore current until they reached Hatteras. There they entered the Gulf Stream and drifted eastward. In general, derelicts entered the Gulf Stream north of 30°N (Cape Hatteras) and moved eastward in the stream. In an area south of the Grand Banks, near 40°N, 50°W, the derelicts appear to have followed either of two divergent paths. Recent measurements have confirmed that the Gulf Stream splits into two bands near the Grand Banks. The first band extends northeastward into the eastward flowing North Atlantic Current, passing north of the Azores. The second extends southeastward and then joins the westward flowing North Equatorial Current. The general circulation indicated by the collected trajectories of the abandoned ships is a large, clockwise pattern split into two branches, one to the north and the other southwest of the Azores. Six derelict vessels moved southward between the Azores and Spain and Portugal.

The large-scale, long-term ocean circulation pattern is characterized by considerable current variability. The derelicts did not usually follow the general pattern smoothly; instead they drifted in convoluted trajectories that often crossed each other. The convoluted paths give an early

A detail of the U.S. Navy's pilot chart of the North Atlantic for March 1888 gives the locations and dates at which derelict ships were sighted. Schematic drawings indicate the conditions of the ships, for example, stern down, bottom up, or mast standing. The paths followed by some identified derelicts are shown by broken lines. Other symbols locate drifting buoys, steamship routes, fog belts, and other vital navigation information.

Defense Mapping Agency



measure of medium-size eddies and of longer-period current fluctuations. We now know that the ocean is populated by energetic eddies that are usually much stronger than the mean currents (the average velocity of the currents). The importance of these eddies to the general circulation has been discovered recently, and they have been studied intensively. Because of these eddies, the mean circulation becomes recognizable only by averaging a great number of observations in space and time. In the Gulf Stream, the North Atlantic Current, and the North Equatorial Current, one clearly sees the general drift in spite of the eddies. In the Sargasso Sea, the trajectories are dominated by the motion of medium-size eddies. The eddies in the Gulf Stream region are important in driving the average flow and determining the character of the general circulation. They also drive a deep eastward flow under the Gulf Stream and a westward recirculation on both its sides.

One should be cautious, however, about ascribing all the motion indicated by the derelicts' trajectories to water movement. Derelict ships varied in size, weight, and the state of damage. Some were totally dismasted and filled to the gunwales with

Built in 1874, the schooner Alice Murphy *was caught in a violent storm in 1915, off the North Carolina coast. The captain and six crew members, who had lashed themselves to the mizzenmast, were rescued, but the waterlogged vessel went adrift in the Gulf Stream. This photograph may have been taken from a tug owned by a New York salvage firm that investigated the derelict. The burned-out wreck of the* Alice Murphy *was later sighted six hundred miles east of New York, where it had been carried by surface currents.*

Collection of W.J. Lewis Parker

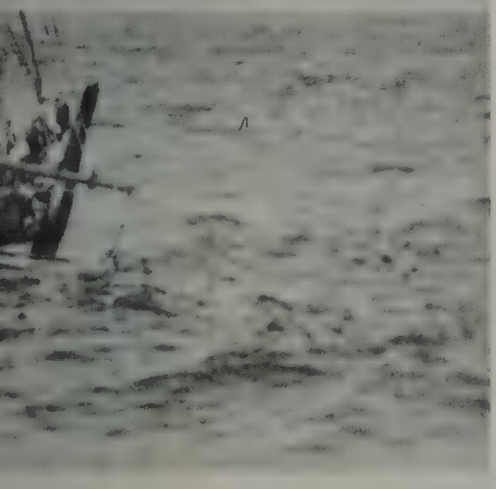
water. These, along with the 30 percent of the sightings of vessels that were turned bottom up, probably provided a good indication of the speed and trajectory of near-surface water. But derelicts with their masts standing and those riding high in the water were no doubt also influenced by wind blowing directly on the masts and the exposed hull.

Additional problems in the effort to interpret the trajectories accurately are position errors of the reporting ships, misidentification of derelicts, and infrequent sightings. The average number of days between sightings was about twenty—this is small enough to indicate some aspects of medium-scale eddies, but it is not small enough to resolve individual loops around the strong eddies, as do today's buoys. Nevertheless, the collection of the trajectories represents a realistic view of the general surface ocean circulation and the variability of currents.

In the nineteenth century, other information concerning surface currents came from ships under way. A ship's course and speed can be estimated in two ways: from its apparent progress through the water, and from its change in position on the earth's surface, as measured by ce-

In a 1965 painting by Gordon Johnson, the crew of the Dei Gratia *sights the* Mary Celeste, *found drifting off the coast of Portugal on December 4, 1872. Apparently the captain and crew had hurriedly taken to a lifeboat several days before; they were never seen again.*

The Atlantic Companies



lestial navigation. The difference, expressed in terms of set (direction) and drift (speed), is attributed to surface currents. Measurements of set and drift were first made in the late eighteenth century, after the introduction of chronometers had sufficiently improved the ability to determine positions at sea. As large amounts of data were accumulated, however, the huge numbers of observations became difficult to handle quantitatively. Therefore, most early summary charts of ship drift observations, such as those shown on the U.S. pilot charts, were schematic and qualitative. Only in recent years, with the advent of high-speed computers, have quantitative and statistical analyses of ship drifts been published.

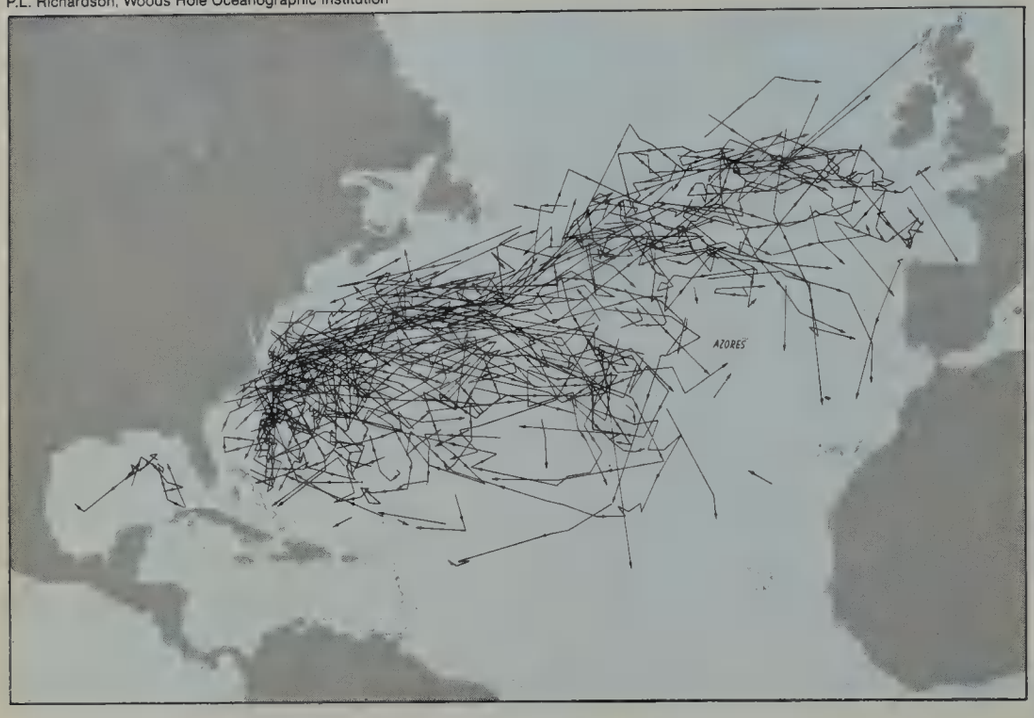
Because of the strong ocean variability, ship drift velocities taken individually or in averaged form do not provide a good measure of where the water actually goes. This key bit of information was provided by the drifting derelicts, which followed the water and provided long-term trajectories of water parcels. In this way the derelict trajectories complemented the measurement of ship drift velocity.

At the end of the nineteenth century, the number of drifting derelicts diminished rapidly. Relatively few derelict trajectories are found in the pilot charts after 1900. There were two major reasons for this decline. The first was the gradual replacement of wooden sailing ships with steam-powered vessels of iron or steel, a change that began in Britain. The second was the successful search for, and destruction of, derelicts by revenue cutters and naval vessels. By 1880, British steam tonnage superseded sailing tonnage, which was falling, and clipper ships could no longer compete with steamships as a means of fast transport. By 1900, the steamship had practically ousted the full-rigged sailing ship from every important trade route on the seas. The triumph of the steamship was a result of the introduction of iron hulls and steel hulls, the development of the screw propeller, and finally the triple expansion engine—a more efficient steam engine—which came rapidly into use after 1880. These developments resulted in stronger ships with more predictable speeds. The newer ships were abandoned less often, and those that were abandoned usually sank.

In America, the transition from sail to steam was more gradual than in Britain. Not until 1894 did American steam tonnage surpass sail in the coastal trade. Coastal sail tonnage continued to grow un-

The superimposed trajectories of drifting derelict ships and a few drifting buoys, as given by monthly pilot charts published between 1883 and 1902, reveal the large-scale pattern of North Atlantic surface currents. The surface water circulates in a clockwise direction, dividing into two smaller currents that move north and south of the Azores. Because of variations over time of the ocean currents, the paths of individual derelict ships often differed from one another or from the general pattern.

P.L. Richardson, Woods Hole Oceanographic Institution



til 1907, when it reached its absolute peak, representing 39 percent of the total coastal tonnage. By far the major part of this fleet of coastal sailing vessels was made up of wooden ships. A study of the casualty pages of the New Marine Register shows that a great many of these vessels continued to be abandoned waterlogged after 1900. But because of a more vigorous, systematic program of derelict destruction by revenue cutters and also by naval vessels, fewer wooden ships appeared as derelicts on pilot charts published after 1900.

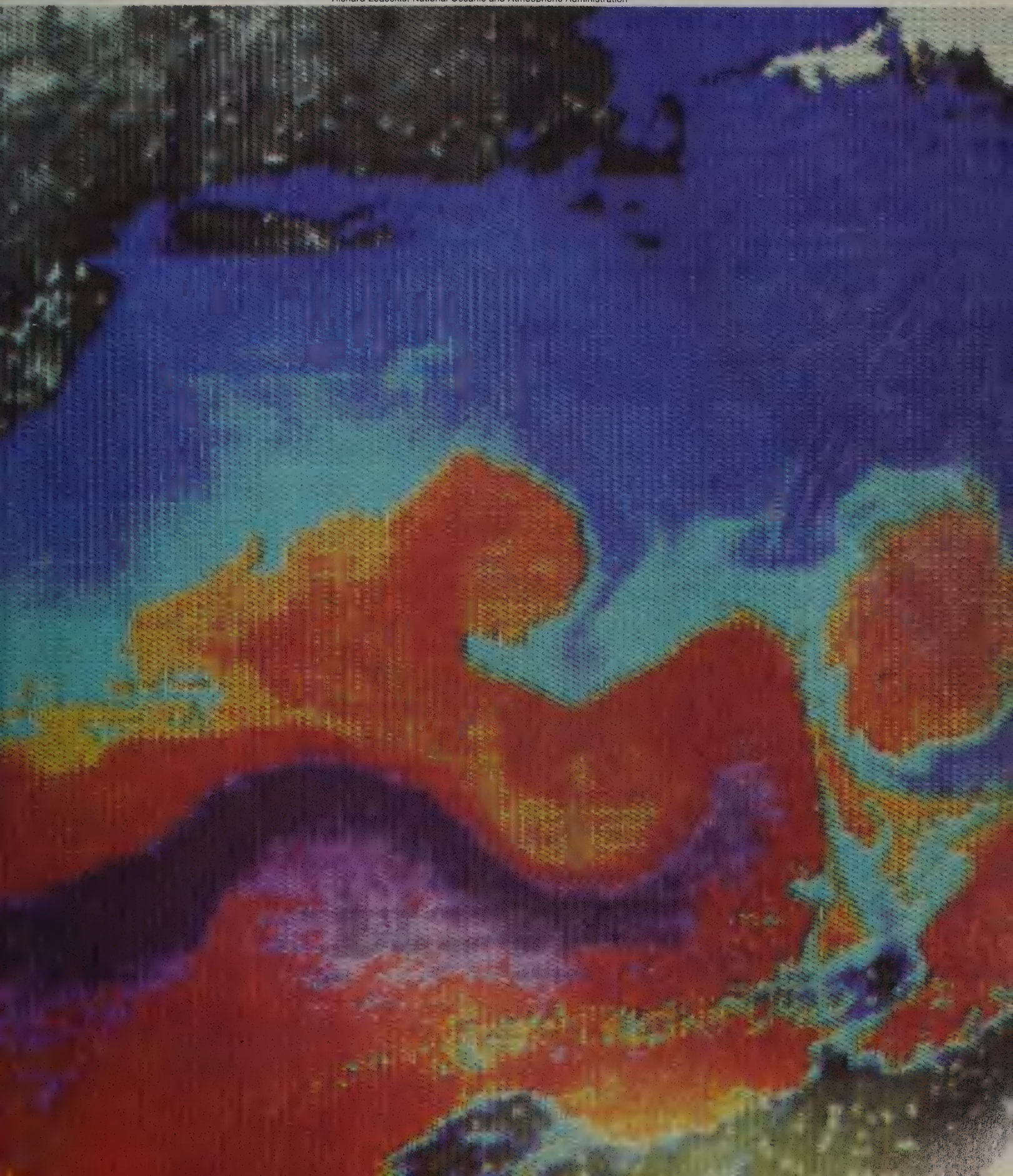
The advent of wireless communication in the early twentieth century made locating a derelict at sea much easier. Positions of derelicts were sent by radio to the cutters so the derelicts could be found quickly and destroyed. Before this method of communication at sea, derelict hunting was at best a haphazard occupation. In 1907, a new revenue cutter, the *Seneca*, was built expressly for finding derelicts and destroying them or, if they were salvageable, towing them to port.

Today the large numbers of drifting buoys (sometimes called drifters) that measure ocean currents are tracked by satellite. The principal areas under study are the North and South Atlantic, the tropical Atlantic, and the tropical Pacific. The ocean's surface layer, directly forced by local winds, is only a thin skin over the mass of deeper water, which has a very different motion. In recent years, deep trajectories in the North Atlantic have been measured by high-tech drifters. These drifters, or floats, are constructed from aluminum tubes that are less compressible than seawater and are ballasted to sink to prechosen depths. Once there, they remain at those depths (like the wooden ships of my childhood reveries) as they drift. Because the ocean is relatively transparent to sound, the floats are tracked acoustically.

Known trajectories of nineteenth-century derelicts still outnumber those of today's buoys, but the newer measurements have the advantage of several fixes per day and a higher positional accuracy. From a collection of these contemporary measurements, we have been able to obtain a more quantitative picture of the general circulation and of the geography of ocean variability. Plots of the buoy trajectories show patterns very similar to those of the derelict trajectories. Although the derelict trajectories were made long ago by methods that now seem primitive, I believe they remain one of the best, if not the best, direct measures of the surface circulation of the North Atlantic. □

In a satellite infrared image of the Gulf Stream off the East Coast, differences in water temperature are coded by color. The purple band is the warm core of the stream; progressively colder temperatures are represented by red, yellow, light blue, and dark blue (white areas are clouds). The patterns reveal meanders and eddies in the Gulf Stream. Modern research techniques have confirmed and refined data gathered eighty to one hundred years ago from the observation of drifting derelict ships.

Richard Legeckis, National Oceanic and Atmospheric Administration



We keep raisi

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g the standard.

Ahhh, but then there were three. Because
on Honda designed another very special
ccord 4-Door Sedan replete with leather
eats, a power Moonroof, fuel injection, dual
ower mirrors, alloy wheels, all standard. And
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The Accord 4-Door Sedan. The Accord LX 4-Door. The Accord SE-i. At Honda, after we set the standards, we keep raising them.

*Based on 1984 calendar year *Ward's Automotive Reports* and EPA Interior Volume Index for subcompacts.

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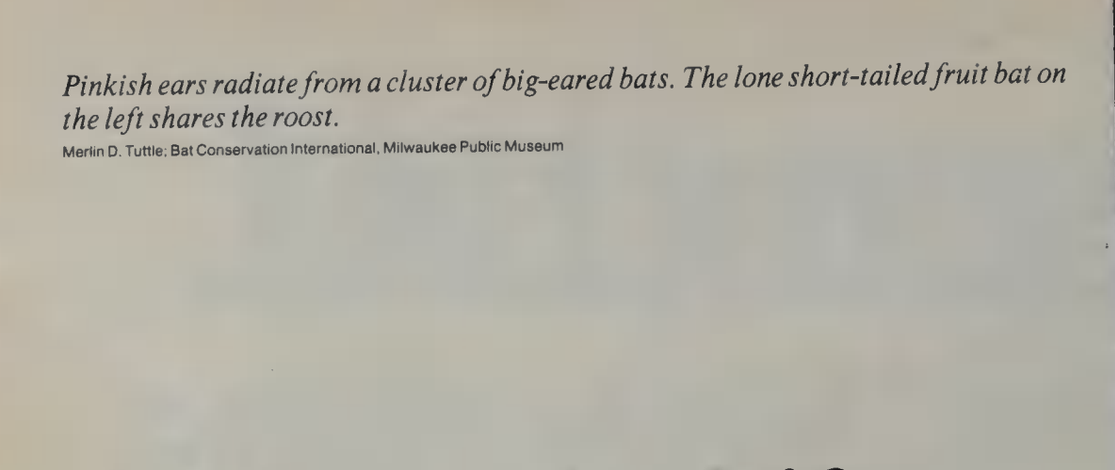
The Accord 4-Door Sedans



Pinkish ears radiate from a cluster of big-eared bats. The lone short-tailed fruit bat on the left shares the roost.

Merlin D. Tuttle; Bat Conservation International, Milwaukee Public Museum

A Day in the Life of a *Piper*-eating Bat

The exploits of a short-tailed fruit bat on a day that almost proved to be ordinary

by Theodore H. Fleming

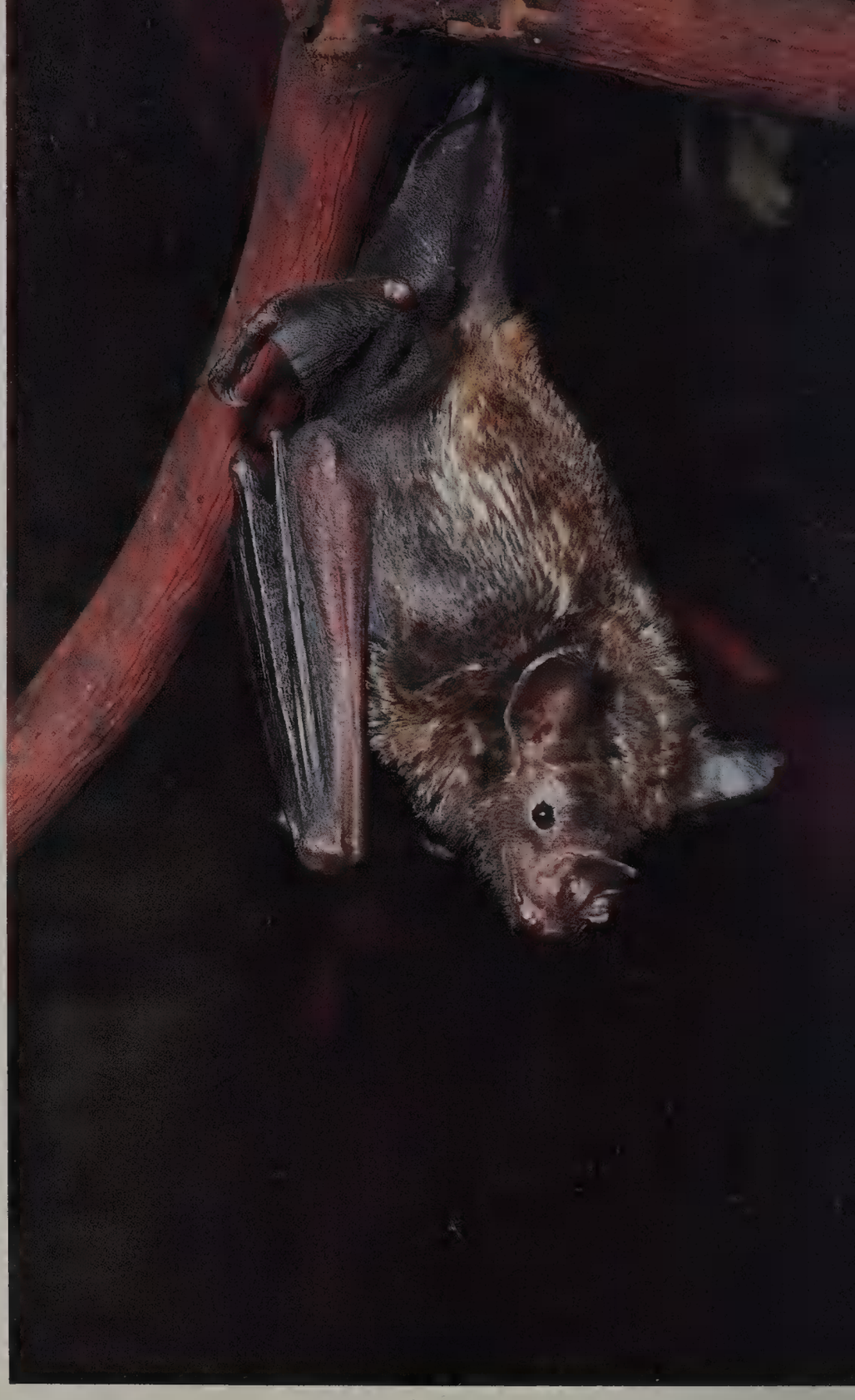
Five-fifteen on a morning in mid-July: the sun's first rays rush into the eastern sky, lighting up a trio of ancient volcanic peaks in western Costa Rica. Twenty-five miles west of the brightening peaks, first light is reaching a rocky stream bed known locally as the Quebrada El Duende (Will o' the Wisp Creek). At this moment, the last of a group of several hundred fruit-eating, flower-visiting bats are returning to a small cavelike tunnel that serves as their daytime roost. As these bats settle themselves on the cave's ceiling, the daytime residents of the creek bed and its surrounding forest are just starting their day. A plaintive *motmot motmot*, the call of a turquoise-browed motmot, echoes among the still-dark leaves, and a black-headed trogon sounds its rattling cry with monotonous frequency. From a nearby hillside, a male howler monkey roars, clearly proclaiming the location of his small troop of six adults and four young. Farther down the creek bed, a troop of white-faced monkeys crashes across the treetops, barking like dogs; they are heading upstream to eat the fruit of some *Cecropia peltata*, or trumpet trees, directly above an entrance to the bat cave.

By 5:30, the five species of bats in the cave have begun their thirteen-hour rest period. Their refuge is a well-illuminated tunnel, eighty feet long and two and a half to seven feet high, formed thousands of years ago by the creek's constant etching away of soft volcanic rock. Among the mass of bats lining the ceiling is a certain female bat—call her a composite of the many bats known to live in the cave.

She is a short-tailed fruit bat known scientifically as *Carollia perspicillata*. Weighing two-thirds to three-quarters of an ounce, *C. perspicillata* bats are medium-sized members of the family Phyllostomidae, the New World fruit bats. Like most others in its family, *C. perspicillata* possesses a nose leaf (a triangular flap of skin directly above its nostrils), which serves as a reflector, helping it direct its low-intensity, nasally emitted ultrasonic echolocation calls. Bats use these calls to communicate with each other, among other things. The short-tailed fruit bat has relatively large eyes (for a bat) and keen vision. Keener still is its sense of smell, which it uses to find ripe fruit. Our bat is chocolate brown, the typical color of this species. Not all the short-tailed fruit bats in this cave, however, are brown; a few are orange-red.

During the day, the female bat hangs by one foot from a tiny projection of the cave's ceiling, alternately sleeping and grooming her fur. Like most other bats, this short-tailed fruit bat grooms herself assiduously, scratching herself rapidly with the claws of her free foot. Periodically she cleans her grooming foot, licking it with the purposefulness of a cat. With this foot, she can reach all parts of her body, including the top of her head. She cleans her wing and tail membranes by licking them.

Although the Duende cave contains nearly equal numbers of male and female short-tailed fruit bats (seventy-five to one hundred of each sex), the two sexes generally segregate themselves into small,



During thirteen hours of daytime roosting, a short-tailed fruit bat hangs by one foot, leaving the other free for grooming sessions, which alternate with periods of sleep. Bats usually do their roosting inside caves or hollow trees.
Doug Wechsler

tightly packed clusters. The females gather near the center of the cave roof. Each group contains two to fifteen females and can be called a harem because it is guarded by a single adult male. Most of the males roost as "bachelors" in a darker, peripheral portion of the cave. Bachelor males are young (usually one to three years old) and have little or no chance of mating with females until they can gain access to a harem, either by fighting with and displacing a current harem male or by quickly taking the place of a harem male that disappears.

Our bat roosts in a tight cluster with ten other females and hence is a member of one of the largest harems in the cave. Her harem male is six years old and has controlled three harems, each bigger than the last, in the past two years. By now he has won many brief but intense boxing matches with other males intent on overthrowing him. The females he guards are a mixed group in terms of their ages and places of birth. About half of them are less than two years old.

As a five-year-old, our female is a relatively old bat; few in this population reach age eight. And unlike most of the females around her, she was born in another cave, two miles away. She remained there for nearly a year, and during this period her fur was bleached orange-red by urinary ammonia fumes in the poorly ventilated cave. Soon after moving to the new cave, however, the female molted and her coat grew in brown. Both male and female bats sometimes leave their natal homes and settle in other roosts before reaching adulthood. The migration rate between the several widely scattered caves in this part of Costa Rica is high enough to create a genetically homogeneous population of *C. perspicillata*.

Our bat has a distinctly swollen abdomen because she is pregnant with a single large embryo. When its four-month gestation period is over, her baby will weigh about a fifth of an ounce—or 25 percent of her mother's weight. After the baby is born in early August, it will nurse for about a month. During its first two weeks, it will cling to its mother's chest and nurse even when she is foraging away from the roost at night. When the baby becomes too large to carry, the female will leave it in the cave roost or in a tree away from the cave while she searches for fruit.

This is her second pregnancy this year. Most female short-tailed fruit bats give birth twice a year, once in late March or early April, just past the middle of this region's six-month dry season, and again about four months later, toward the middle of the wet season. The timing of births coincides with the two annual peaks in fruit growth in this strongly seasonal habitat. Once a mother stops nursing her baby, she has relatively little contact with her offspring, although daughters are likely to remain in their mother's harem for some time before joining another harem in the same cave or another cave. Males leave the harems at an early age and join bachelor groups, usually in their natal caves.

It is now just past noon, and the sun has passed its zenith. The cave is still comfortably cool, although the outside air temperature is nearly 92 degrees Fahrenheit. The air is still and heavy, a sure sign that an afternoon shower is approaching. The area that shades and surrounds the creek bed is tropical dry forest. During the dry season, most trees lose their leaves, and

Prompted by the heavy rains of late spring, the tropical shrub Piper amalago, *below, a staple and favorite food of short-tailed fruit bats, produces fruiting spikes. The plant depends upon bats for seed dispersal. Bats seize the high-protein fruit while on the wing and may carry it some distance through the forest before stopping to eat. The seeds consumed with the fruit are quickly excreted, often at the feeding site.*

T.H. Fleming

from February through April, the forest floor is covered with a thick carpet of dry leaves. In moister places, the common understory shrubs are nondeciduous members of the genus *Piper* (family Piperaceae). Five species inhabit this region of Costa Rica. *Piper* shrubs play a particularly important role in the life of *C. perspicillata*, for the bats are partial to their fruit. Although *Piper* fruit generally have no commercial value, the seeds of one species, *P. nigrum*, are used worldwide as black pepper.

In mid-July, the fruit of *P. amalago*, a multiple-stemmed, six- to nine-foot shrub, are beginning to ripen; the seeds are dispersed exclusively by four species of bats. As is true for all dry forest plants, *P. amalago*'s flowering and fruiting biology is strongly tied to seasonal changes in rainfall. During most of the dry season, these shrubs bear immature inflorescences—spikes with flowers up and down their length—that emerge near the tips of the upper branches. As soon as the wet season begins, in late April to mid-May, the inflorescences start to lengthen, eventually becoming spikes 1.5 to 2.4 inches tall bearing several hundred tiny flowers. Two to three weeks after the rains begin, *P. amalago* will be in heavy flower, and its white inflorescences will be visited by a diverse array of pollen-collecting insects, including stingless bees, sweat bees, leafcutter bees, and syrphid flies. These insects play a crucial role in moving *P. amalago* pollen among the inflorescences. If insects don't visit the *P. amalago* shrubs, they produce very little fruit; if pollinated, each flower on the spike will produce a single-seeded fruit. Generally, each spike bears one hundred to two hundred fruit. As it matures, the fruiting spike (hereafter called a fruit) turns green and resembles a small sweet pickle.

P. amalago is only one of three *Piper* species whose growth is stimulated by the rainy season. Because of differences in inflorescence length or growth rates, the other two species, *P. pseudofuligineum* (which has inflorescences about three inches long) and *P. jacquemontianum* (which has thicker, slower-growing inflorescences), flower later in the first half of the wet season. The slight differences in scheduling allow these three *Piper* species to share their pollinators without too much competition. The other two species, *P. marginatum* and *P. tuberculatum*, have flowering (and fruiting) periods that also differ from the others. *P. marginatum* flowers after a brief spell of dry weather that usually occurs in July, and *P. tuberculatum*, a creek side species, flowers in March and April during very dry weather. All in all, the five *Piper* species supply *Carollia* and other bats with a continual and reliable food supply for several months each year.

This year's wet season began in mid-May, so the fruit of *P. amalago* are just ripening. The crop of each plant ranges from ten to more than two hundred fruit. Usually fewer than five fruit ripen daily on each plant during the three- to four-week fruiting season. The first night they are available, nearly all the ripe fruit are taken by bats.

At 2:00 in the afternoon, the sky quickly darkens and, accompanied by thunder and lightning, a brief but intense shower dumps a tenth of an inch of rain on the forest. Howler monkeys roar in protest but eventually become resigned to another soaking. White-faced and spider monkeys and many species of birds sit quietly under the partial protection of the leafy canopy and wait for the storm to pass on to the west.

Other than seeing a small trickle of water flow through the Duende cave, our female *Carollia* and her roost mates are unaffected by the afternoon precipitation. However, at other times in the rainy season, especially in late May or early June and again in September and October, heavy rains fall for several hours daily for a week or more. At these times, the Quebrada El Duende is a rushing river that completely floods the cave, causing the bats to seek shelter in nearby hollow trees or in rocky crevices downstream. Except for these relatively short interruptions, the cave remains a cool, dry refuge for the bats.

By 3:30 the storm has passed, and the bright, late afternoon sun begins to dry off the vegetation. As it sinks lower, the sun illuminates more and more of the coppery red trunks of one of the common trees in the dry forest, *el indio desnudo* (the naked Indian tree, *Bursera simarouba*), turning them into fiery pillars in a mosaic of glistening leaves. As the afternoon sunlight fades, daytime birds and mammals briefly increase their feeding activities before returning to their roost trees, vines, or dens for the night.

The Duende cave bats are restless by late in the day; at sunset, they start to leave. The first species to go is a half-ounce fruit and nectar eater, the long-tongued bat, *Glossophaga soricina*. At about 6:20 these delicate bats depart quickly and fly either singly or in small groups to search for an evening's meal. For most of the year, *G. soricina* bats eat a variety of fruit, including many of the same species consumed by *C. perspicillata*. In the dry season, however, *G. soricina* feeds on nectar and visits several night-blooming species, such as the legume shrub *Bauhinia ungulata*, and trees such as *Inga vera, Hymenea courbaril, Ceiba pentandra* (the commercial source of kapok), and *Bombacopsis quinata*.

The short-tailed fruit bats leave the cave between 6:30 and 7:00 P.M. By the time the female stretches her wings and makes a couple of warm-up flights around

A landing, a foothold, and a quick chomp, and the bat is off to savor a bite in the safety of a concealed night roost.
Richard LaVal

the inside of the cave, most of her harem mates have already left. At 6:45 she darts out the upstream end and turns north, flying through relatively open parts of the darkening forest at a speed of twelve miles per hour. In five minutes she reaches a small patch of *P. amalago* where she has fed for the past three nights.

Upon arriving at her first feeding area, she flies over the shrubs and quickly locates a ripe fruit by its slightly sweet smell. She grabs the fruit in her mouth while still in flight. It easily detaches from its thin branch, and she carries it to a dense bower of leafy vegetation—her night roost—about forty yards away. She will use this roost, chosen for the amount of cover it provides from predators, for as long as she visits this patch of plants. Hanging on a vine, she holds the fruit between her wrists and bites into the juicy pulp and small, bullet-shaped seeds, while rotating the fruit corn-on-the-cob style. In less than a minute and a half she has devoured most of the pulp and seeds from the fruit's central stem, which she now drops. Flying back to the patch, she picks another fruit and returns to her night roost to eat. After eating two more fruit this way, she stops to rest.

Now, having eaten four fruit, she's full and rests quietly, often sleeping, until her stomach empties. Fruit pulp and small seeds move rapidly through *C. perspicillata*'s relatively short digestive system, and she begins to excrete most of the seeds from her first fruit in twenty minutes. These seeds, as well as most of the others she has recently swallowed, will be deposited on the ground beneath her night roost.

Because the bat has used this same roost for several nights, hundreds of *Piper* seeds have fallen in a small area. This concentration of seeds will, within a day, attract the attention of several species of seed-eating animals, including harvester ants of the genus *Pheidole* and a spiny pocket mouse (*Liomys salvini*). The ants will carry many seeds to their nest and either eat them or store them for future use. The pocket mouse will eat many of the one-tenth-inch-long, spicy seeds immediately. Others it will place in its fur-lined cheek pouches and carry back to its burrow. As the mouse rummages through the leaf litter looking for more *Piper* seeds, it inevitably will push a few seeds into crevices in the soil where they can't be detected by seed predators.

Many of the plants producing fruit eaten by short-tailed bats are short-lived, early successional species whose seeds lie dormant in the soil until a disturbance—a tree fall, a forest fire, or the collapse of a stream bank—exposes the seeds to the levels of light required for germination. From a plant's point of view, *Carollia*'s major service is to distribute large numbers of seeds throughout the forest, thereby replenishing the soil seed bank. Seeds deposited in actual or incipient light gaps have the greatest probability of germinating and eventually providing food for new generations of frugivores.

While the bat is resting, her roost mates also feed or rest at various locations away from the roost. Two other females and a bachelor male, as well as several *G. soricina*, are feeding in this *P. amalago* patch. These bats often encounter each other as they search for fruit, but they do not fight or try to defend food patches. Mainly, they ignore one another and operate independently. Because the amount of fruit is limited, the bats do compete for it, but more by scrambling for access to it than by interfering with each other.

At this time of the year, food levels are high and most short-tailed fruit bats living in the Duende cave feed within a mile of the day roost. They go to a variety of areas north of the roost and others either east or south. In the dry season, when fruit is much more widely scattered, individuals must fly about twice as far from their roost, often far to the west and south, to find food.

Female and bachelor short-tailed males don't seem to have any particular social conventions about where they feed. However, females usually do not eat near their harem mates or their harem males. Bachelor males pay little attention to which bats are in the neighborhood when they're feeding. Only male bats with harems feed in predictable locations: because they often have to defend their roosting sites against other harem males or older bache-

lors at night, they usually stay within 500 yards of those sites. To get food, these males generally dart out of the cave, grab a fruit, and return with it to their territory. Most of the seeds they eat are excreted in the cave rather than in the forest.

After about an hour's rest, the female bat is ready to feed again. She returns to the same patch, but it takes her a bit longer to find two ripe fruit because of the other bats feeding there. After eating the two fruit, she rests briefly and then flies 220 yards east to another *P. amalago* patch she discovered two nights ago. She eats three more fruit here, then sleeps lightly for another hour. Again she excretes nearly all of the seeds she has recently ingested, including some seeds from her first feeding site, under this second night roost. So far this evening, she has done little to scatter the seeds she has consumed. Most have fallen on vegetation or on the ground within about 50 yards from their mother plants, but some have become intermingled with seeds from a different *P. amalago* patch. Over the years, bats move *P. amalago* seeds to many locations, sometimes miles away from their origin, and thus affect these patchily distributed plants by making their population's genetic structure more homogeneous.

After eating two fruit, the female bat moves again, this time about a mile southeast, to a *Cecropia peltata* tree growing along a creek bed. Prior to the ripening of *P. amalago* fruit, she fed almost exclusively at this tree for several weeks. Like plants in the genus *Piper*, *C. peltata* trees bear only a few ripe fruit each night, but they do so for several months, rather than several weeks. *C. peltata* fruit contain hundreds of small seeds and are much larger than *Piper* fruit. Rather than carrying off an entire fruit, a short-tailed fruit bat must land on the 2¾-inch-long *C. peltata* fruit, bite off a small chunk, and carry that to its night roost to eat. Just two or three entire *C. peltata* fruit could fulfill a bat's daily energy requirement of about nine kilocalories, compared with thirty-five to forty *Piper* fruit. But even so, the short-tailed fruit bat prefers the smaller fruit, probably because its pulp is richer in

protein, a critical nutrient for small frugivorous mammals, and because it contains less nondigestible plant fiber per unit measure.

The female bat makes two visits to the *C. peltata* tree from a new roost, which here is in the crown of a large *Pithecellobium saman* tree located thirty-five yards upstream, before resting forty minutes. She naps, and upon waking grooms herself briefly before departing for the *C. peltata* tree again. Her flight path takes her across the silver sliver of a late-rising moon, a movement that catches the attention of a mottled wood owl (*Ciccaba virgata*), perched twelve feet away from the fruit tree. Launching itself silently from its perch, the owl intercepts the bat five yards short of her goal. The bat dies instantly as the talons of the owl's right foot pierce and crush her chest. The owl, normally a hunter of small rodents such as the spiny pocket mouse, has chosen tonight to concentrate on bats flying into a fruiting tree. Its success rate has been good; it has killed two short-tailed fruit bats in four attempts.

By dawn the owl has regurgitated the skull and crushed limb bones of the female bat near its own sleeping roost deep in the forest. At the Duende cave, the bats, with one or two exceptions, have returned to their roosting places. Our female's only surviving offspring, a two-year-old female, lives in a small harem six feet from her mother's. She is pregnant and will give birth to a male in one month. If lucky, perhaps she too will live to be five years old. She will have to be constantly vigilant to survive that long, however, for bat predators are common in this habitat. In addition to various owls, these include snakes, arboreal opossums, and the largest New World bat, *Vampyrum spectrum.*

As the bats begin their thirteen-hour rest, the white-faced monkeys descend from their sleeping trees to feed on *C. peltata* fruit near the cave entrance, and a turquoise-browed motmot starts to issue its monotonous call from a low branch in the nearby forest. At Quebrada El Duende, the daily cycle has begun again. □

A frog-eating bat swoops in at the base of a large hollow tree, while a short-tailed fruit bat, probably on a fruit foray, enters the dense forest understory.

Merlin D. Tuttle; Bat Conservation International, Milwaukee Public Museum

New Life on the Mississippi

The great river is building itself a new delta at the mouth of Louisiana's Atchafalaya River—its future path to the sea

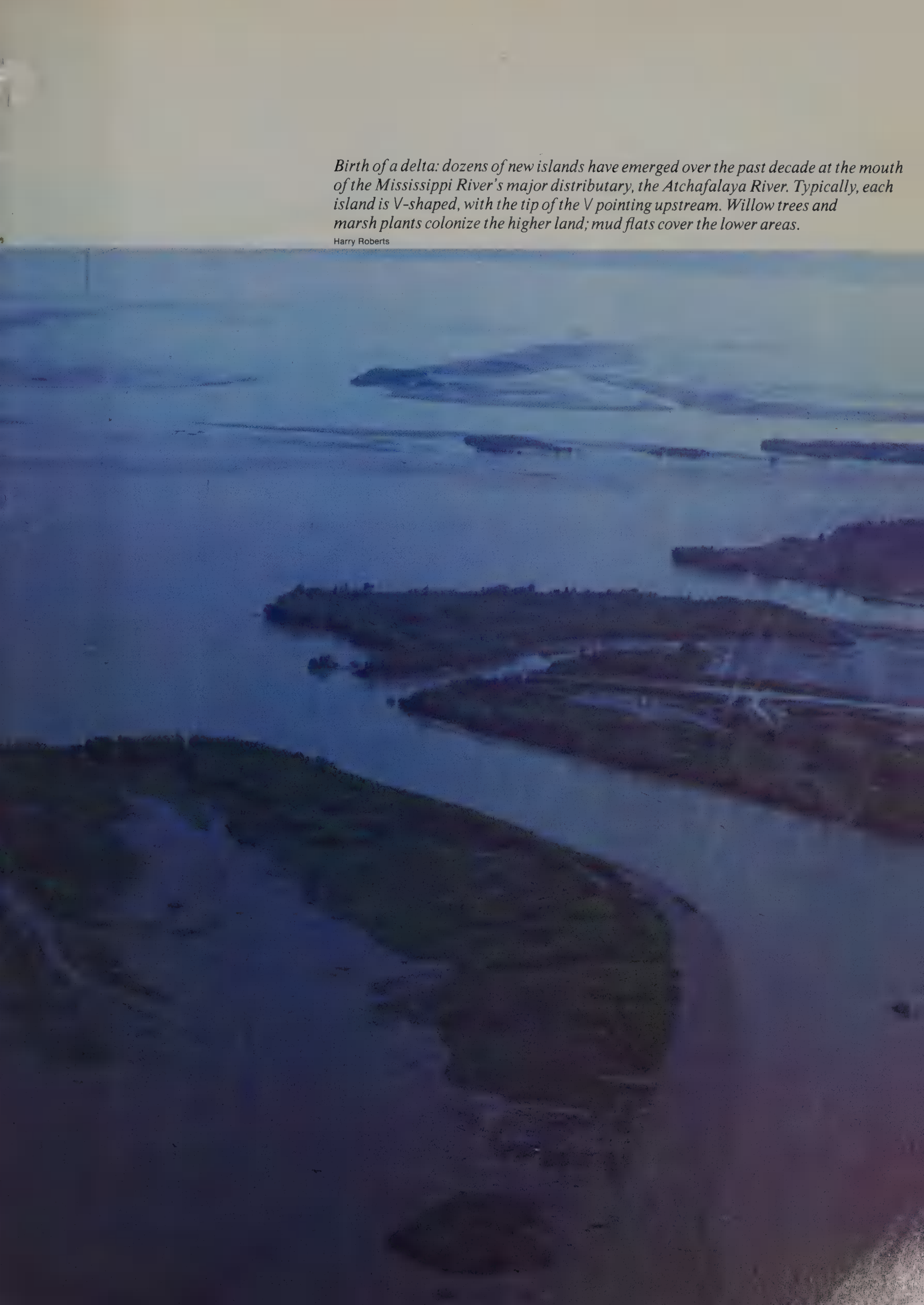
by Linda A. Deegan and Christopher Neill

As an early April morning fog begins to lift, we pilot our nineteen-foot Boston Whaler—with its three-person crew and cumbersome cargo of trawls, seines, ice chests, and countless empty bottles and jars—toward the edge of a marsh. In the middle of a channel we have successfully navigated for almost a year, the sudden low-pitched groan of the engine tells us we've hit mud. So we get on the push poles, trying to use the position of several willow-covered islands in the distance to guide us to deeper water.

Finding ourselves hard aground in a spot where we floated easily just one month ago comes as no real surprise to those of us studying one of nature's most dynamic ecological events—the emergence of a new river delta. And when the new delta is being built by one of America's major rivers, the Mississippi, every little change seems like big news. The new delta, and the Mississippi's inevitable new meeting place with the sea, lie 120 miles west of the current outlet and well west of the city of New Orleans, at the mouth of what is now the great river's most important distributary, the Atchafalaya River.

At least six times since the sea rose to its current level at the end of the last ice age, the Mississippi has shifted course, abandoning an aging, deteriorating delta and building a new one. All of coastal Louisiana was created in the process. Each delta was built out of the same material—topsoil imported from 2,000 miles upstream, where the Mississippi cuts through the American heartland. Hundreds of millions of tons of soil are picked up by the river and carried to the shallow coast of Louisiana each year. As any delta grows and matures, the river channel becomes choked with sediment and carries water less and less efficiently. The river's path becomes longer and more sinuous. In response to the back pressure on the system, the river starts shunting more of its flow down a distributary channel that branches off far upstream. The smaller channel carries the sediment that initiates formation of the new delta; eventually it captures the river's entire flow.

This is the fundamental mechanism by which the Mississippi's deltas have been



Birth of a delta: dozens of new islands have emerged over the past decade at the mouth of the Mississippi River's major distributary, the Atchafalaya River. Typically, each island is V-shaped, with the tip of the V pointing upstream. Willow trees and marsh plants colonize the higher land; mud flats cover the lower areas.

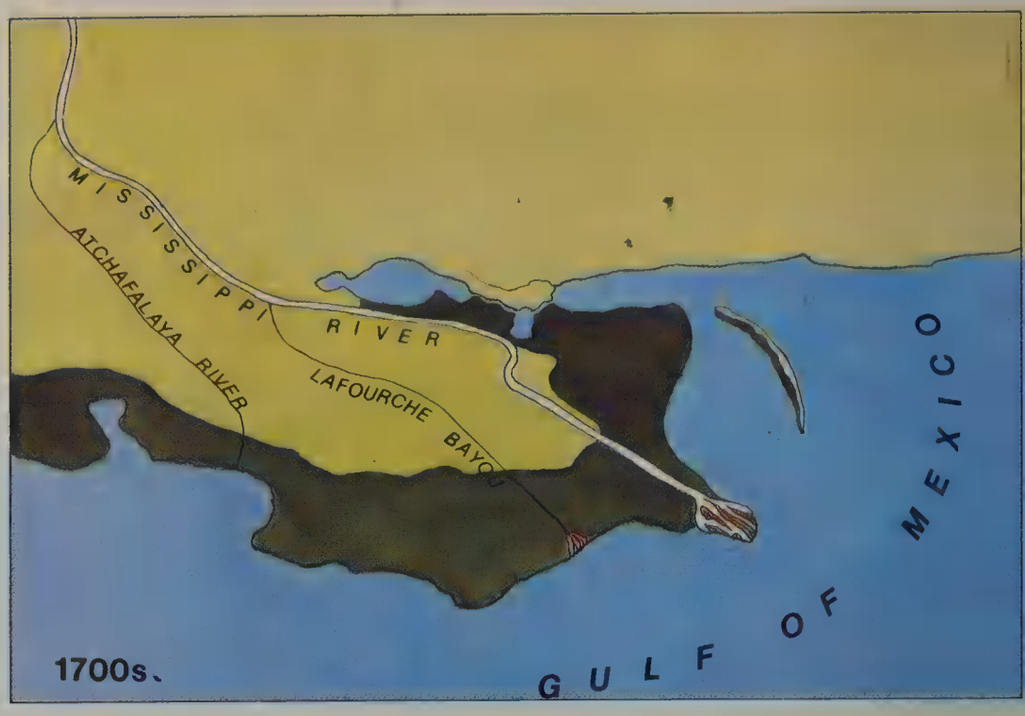
Harry Roberts

built. During the past two decades, a new delta has emerged at the mouth of the Atchafalaya (a Choctaw Indian word meaning long river, pronounced *A-cha-fuh-lie'-yuh*). It is the newest in a chain of Mississippi River deltas with historic and colorful names, like Maringouin (6,200 to 7,200 years ago) and Teche (3,900 to 5,700 years ago), the more recent Lafourche (60 to 3,500 years ago), and the current Plaquemines-Balize (1,000 years ago to present).

The Atchafalaya River was a distributary of the Mississippi as far back as the 1500s. During the middle and late nineteenth century, logjams at the junction between the rivers and continual dredging of the Mississippi's navigation channel prevented the big river from flowing freely into the offshoot. In 1839 the logjams were cleared to aid navigation, and a new phase began in the formation of the delta. More and more water flowed into the Atchafalaya; now the branch river is threatening to take over the last leg of the Mississippi's trip to the Gulf of Mexico.

It certainly would be a straighter run. From its junction with the Mississippi 45 miles northwest of Baton Rouge, the Atchafalaya sprints 140 miles, most of them straight south, to the coast. The Mississippi itself lumbers along another 330 miles from that same junction before spilling into the Gulf. The Atchafalaya has the laws of physics on its side. By the early 1940s, researchers were predicting that, without human intervention, the Mississippi would change course by 1975. But the U.S. Army Corps of Engineers did intervene. In the 1940s and 1950s army engineers built levees to contain the Atchafalaya; in 1963, they added a dam known as the Old River Control Structure. Now, no more than 30 percent of the Mississippi's waters are allowed down the Atchafalaya at any given time.

Still, a lot of ecological work is being done. Millions of tons of new sediment are delivered to the Atchafalaya delta each year. On its way, this underwater cargo clogs shipping channels and creates a headache for the Army Corps of Engineers. But this is the stuff that turns an open bay into a river delta, and changes at



Diane Baker

The Mississippi River's current Plaquemines-Balize delta, top left, was expanding (red) in the eighteenth century. By the late nineteenth, more water and sediment were going down the Atchafalaya. For years, the sediment was trapped inland in lakes and bayous. By 1950, middle left, most of those water bodies had filled in (green) and some particles began to be carried into Atchafalaya Bay. These laid the groundwork for the new delta. The first islands, bottom left, appeared with the 1973 spring flood; more have emerged since then. During the same period, the Plaquemines delta eroded. Olive green areas are coastal marshes. Below: A Cajun lumberjack camp along the Atchafalaya River, in 1880. Many Cajuns live off the land in the Atchafalaya basin today.

Special Collections Division; Howard Tilton Memorial Library; Tulane University

the mouth of the Atchafalaya have been startlingly rapid.

As we steer our boat from the mouth of the Atchafalaya into the bay, the landscape opens up and all we see is sky and water; the horizon is broken only by the outline of small, tree-covered islands. These are the closest things a delta has to terra firma. As a group, the islands are spread in the shape of a tree, but this is only visible from above. From a motorboat, the area seems small, almost unremarkable (the islands cover only about 5 percent of the bay), but there is more to a delta than what appears on the surface. In most places, the water is only six inches deep. Below that are shoals, sediment-filled areas that are not yet land but no longer belong exclusively to the sea. These shallows are the trademark of any delta.

If we tie up at one of the bigger islands and hike to the tangled willow trees that usually grow at the highest point, we can see marshes. They start below the willows and extend several hundred yards. The marshes lie at a lower elevation than the willow-covered headland, and they exist in the nether world created by the changing water levels. The plants are adapted to the constant rise and fall of river water and can survive for long periods with just their leaves above the surface.

Beyond the marshes are the mud flats. Like the marshes, they are flooded at high water and uncovered at low, and they extend out into the distance as far as we can see. An island's mud flats are easily ten times the size of the island itself. Anybody who walks from the willowed island head through the marsh and out onto the back flats is asking for a mud bath—in some places up to the waist. It is a difficult place for humans to move around in. We have often wished there were special skis that would let us skim over the slick surface, but no matter what we rig up, we still sink with every step. Although a mud flat is under water most of the time, we can judge its size by looking for the protruding skeletons of trees. Huge ones are washed down the river every spring, and wherever we see these ungainly markers, we know there are flats beneath them.

Although they seem barren, mud flats are extremely productive habitats. Under the thin sheet of water is a film of tiny plants—golden diatoms and green filamentous algae. The flats are cut by an intricate network of bifurcating channels that carry nutrient-rich waters to a host of small animals that live in the soft mud. Taken together, these mud flats, along with the marshy, willowy islands, cover about thirty square miles. These, for now, are the limits of the new delta.

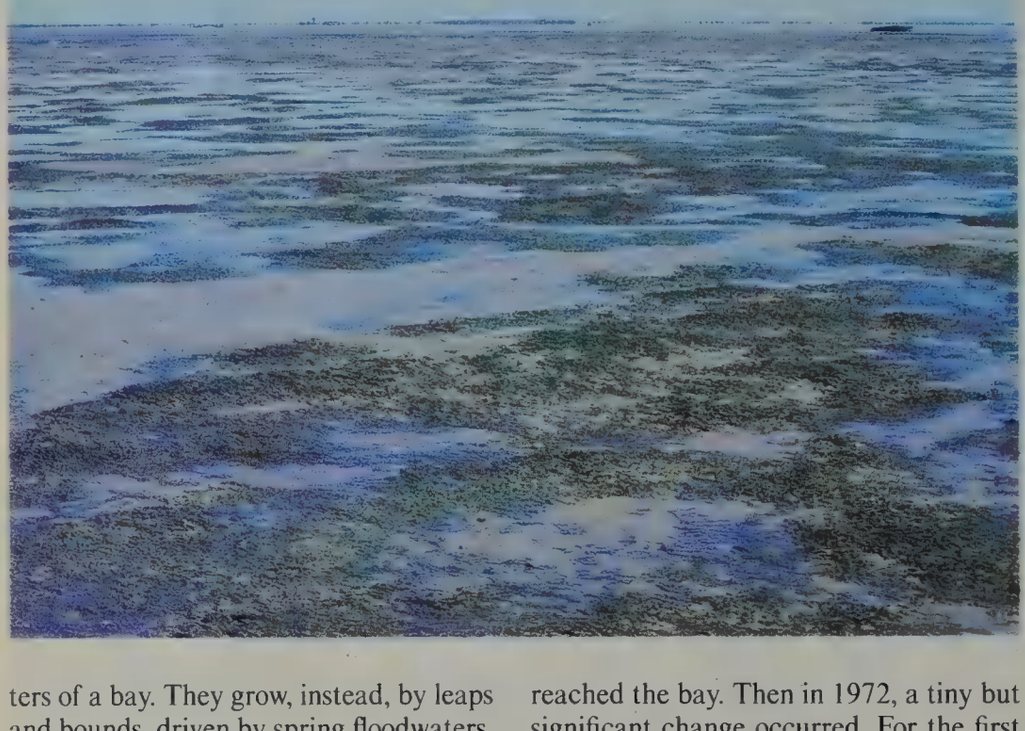
Scientists from the Center for Wetland Resources at Louisiana State University have been studying the delta since its inception in the 1950s. We joined this research team five years ago, and much of what we have learned has depended on the work of many others.

One thing we learned pretty quickly was that deltas do not march in a steady and regular fashion into the shallow wa-

Dan Guravich

An island's mud flats, below, are prime feeding grounds for birds and fish in the Atchafalaya delta. The mud is full of worms, and tiny plants cover the surface. The material that built the mud flats is sediment delivered by the Mississippi into the Atchafalaya at the junction of the two rivers, right. The dam known as Old River Control Structure (center) limits the amount of water flowing from the Mississippi into the Atchafalaya, preventing the big river from changing course.

Ron Paille



ters of a bay. They grow, instead, by leaps and bounds, driven by spring floodwaters. The first sediment showed up in Atchafalaya Bay in the 1950s. But for half a century before that, floods had laid the groundwork. During those years, the silts and sands that spilled out of the Mississippi into the Atchafalaya were trapped in the Atchafalaya's inland flood plain basin—essentially a giant swamp laced with lakes and bayous. Only after most of these water bodies had filled with sediment did large amounts of material flow south into the bay.

The first arrivals were very fine-grained clay particles, which are light and easily transported. At first most of them overshot the bay and ended up in the Gulf of Mexico. There they drifted west and piled up along the Louisiana coast, forming gooey mud flats up to six feet thick.

The specks of clay and slightly heavier silt that did settle out in Atchafalaya Bay began to accumulate and to form a broad, flat underwater shelf, called a prodelta platform. The process fed itself—the more the sediment piled up, the shallower the bay became, and then even more sediment could be trapped. This pattern continued for twenty years. With each spring flood came a new load of sediment, which skimmed over the inland sinks and reached the bay. Then in 1972, a tiny but significant change occurred. For the first time, sands—much heavier than silts and clays—slipped past the flood basin. With these particles in the mix a new phase of delta development began.

It could have taken years, but instead it happened the next spring. In 1973, a great flood swept through Atchafalaya Bay, affecting waters as far as fifteen miles offshore and forty miles to the west. The Atchafalaya River hit a peak, carrying five times its average volume. When these rushing, silt-filled waters reached the bay, they slowed down and a number of intriguing things began to happen.

First, some of the river became part of the bay. It happened when sediment fell on either side of the river's main channel, forming natural underwater banks. Simultaneously, the river dropped sediment onto its own mouth, which piled up in its path and created a shoal. Because of the particularly important location of the shoal, it's called a distributary mouth bar. More and more sediment piled on; the bar grew in height and width, and before long the obstruction broke the surface and caused the river to split. Now there were two channels, but soon there were four, as new bars bisected the channels again. When the 1973 flood was over and the floodwaters moved on into the gulf, they left behind the beginnings of the new delta—with its present configuration of islands (distributary mouth bars) and channels but no vegetation. These were the first delta islands.

The flood of 1973 was followed by others in 1974 and 1975. These were not as big as their predecessor but they piled more mud on the newly formed mud flats and channel banks. Over this three-year period, 183 million cubic yards of sediment was deposited in the delta—enough to bury the entire state of Connecticut under a half-inch of glop. Floods in 1979 and 1983 added even more. Each of these floods enlarged the original islands and added new ones. Now there are sixty-two of them, ranging from a few square feet to twenty acres.

There is a characteristic shape to all of

the islands. It is a V, whose tip points upstream. The arms of the V are the banks of the new channels on either side. The tip and arms are the highest points because, facing upstream, they receive the greatest supply of sediment. The lower interior trails off into the mud flats.

Since new delta islands are virgin land totally devoid of vegetation, they offer an unusual opportunity to study primary plant succession. To colonize new delta land, plants must be opportunistic species, adapted to changing environments. Their seeds must be able to travel far and grow quickly. Then, once they've gained a foothold, they have to be able to tolerate frequent flooding and a continuous barrage of new dirt.

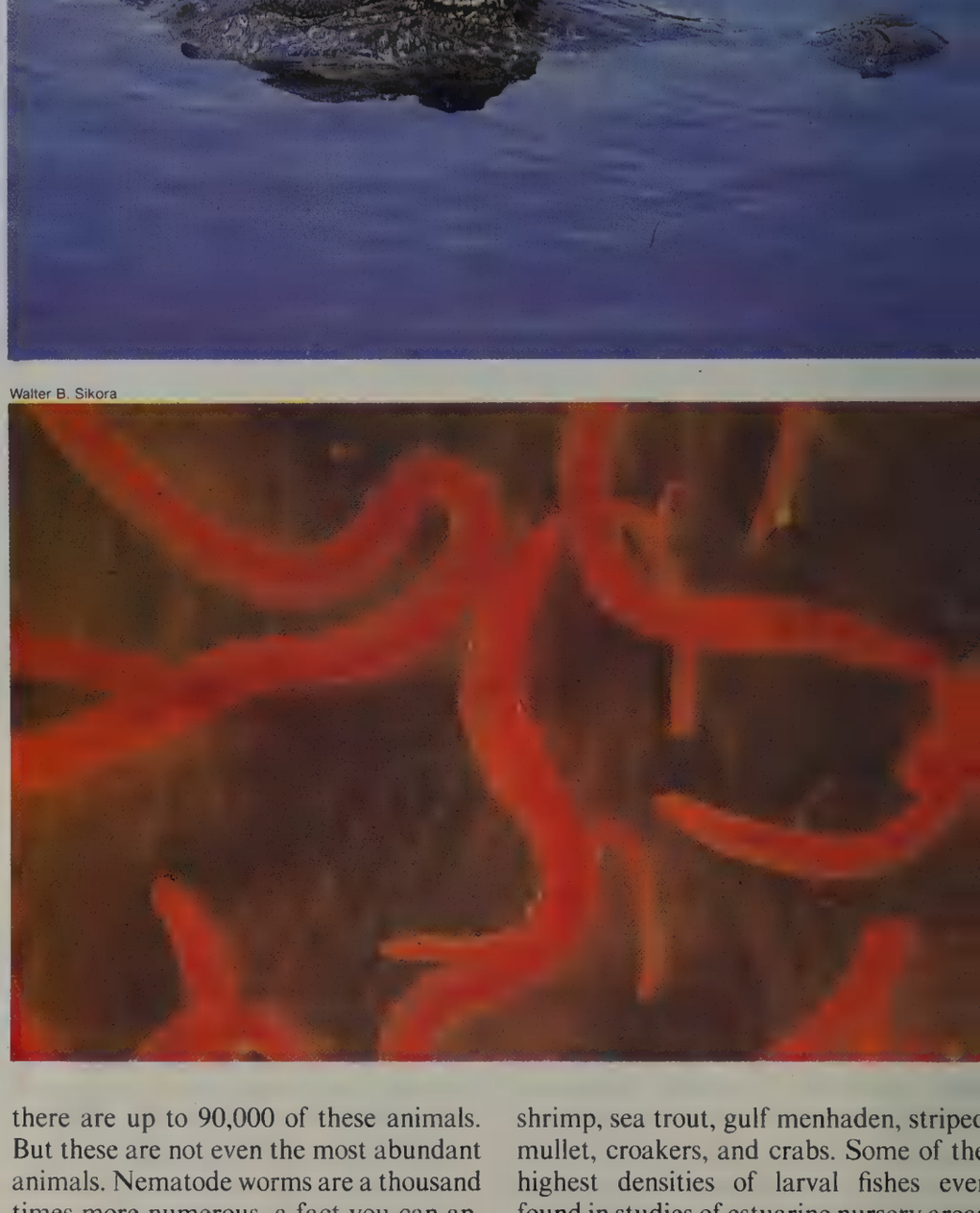
Arrowheads, several species of fleshy, broad-leaved marsh plants, have not only coped with these problems; they seem to thrive on them. They have pioneered every new island in the Atchafalaya delta. Able to establish themselves in one season, arrowheads are superbly adapted for colonizing. Their flat seeds float downstream on the river. As soon as they hit land, their membranous wings help stabilize their position in the soil. There are other resourceful marsh plants, like rushes and sedges, but arrowheads are unique because they produce underground tubers. At the end of the first growing season, the top part of the plant dies back for the winter, and energy—in the form of starch—is stored in the tuber. This strategy allows the plant to sit out the worst rages of the spring flood and then, when the water level drops back to normal, to draw on reserves and grow.

Arrowheads take the high ground first, colonizing the upstream edge of the islands, which can be as much as a foot above average water level. Elevation is crucial here, for even a couple of inches alters the amount of time plants stay submerged; and when a plant is being pushed to its physiological limits, a few extra hours underwater can kill it. Inches also determine species distribution. Broad-leaved arrowhead thrives on slightly raised portions of the islands; but delta duck potato, its close relative, can grow almost completely underwater and occupies lower portions of the mud flats.

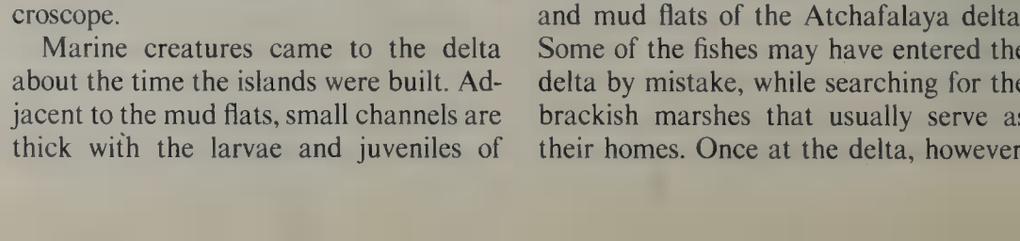
The growth of vegetation after the 1973 flood followed a pattern that seemed curious at first. No plants at all sprouted the first year. By the end of 1974, however, vegetation covered 219 acres. By 1975, after yet another flood, 380 acres had been colonized by plant life. But the most surprising change came the following year. Little new sediment had been deposited

Alligators, below, are predators at the new delta; they go after fish and, sometimes, birds. Other important prey are nutria, facing page, slow-moving, semiaquatic rodents whose thick fur is sometimes sold as "simulated" mink. Herbivorous, nutria live in marsh areas on the delta islands. Oligochaete worms, bottom, live in mud flats and are usually concentrated in the top inch of mud. Both birds and fish feed on them.

Dan Guravich



Walter B. Sikora



during the spring flood of 1976, but when scientists surveyed the vegetation later that year, they found the delta's colonized area had more than tripled, to 1,117 acres. What we have come to understand is that low flood years actually encourage plant growth. Plants are submerged in the cold, turbid water for a shorter period, and as a result they get more light and the soils stay warmer. Ultimately, high and low floods work together: highs bring the land and seeds, lows encourage plant growth.

Arrowheads are the original settlers, but when the river adds another foot or two to an island, black willow trees appear. Black willows are the best tree colonizers of wet, low-lying areas. Their silky-haired seeds come by wind to the delta, and they come by the millions. When willow seeds fall onto a suitable spot for germination—much too wet for most other trees—they grow like crazy, producing a twisted tangle of trunks that is difficult to penetrate. Most important, willows stabilize the ground they sit on, trapping new sediment and using their tough stems to protect the marshes from river currents.

Until now, the river itself has controlled island development by determining elevations and sedimentation. But once willows are established, the river's power is more limited. Plants now have an influence. An array of them follow the willow in—towering cattails, roseau cane, softstem bulrushes and spike rushes, alligator weed, among others. Annual flowering plants such as goldenrod and asters take hold on the highest and driest ground. Eventually, the marsh on the downstream side of the island gains a measure of independence from the river.

But not all the residents of the delta are immigrant plants. One of the unique characteristics of the new land mass is that saltwater and freshwater organisms seem to be able to coexist there. Some of the most prominent, but least visible, marine inhabitants are in the mud. Polychaete and oligochaete worms—the aquatic equivalents of earthworms—snails, tube-building crustaceans, and the larvae of midges all live in the mud. Many of these are concentrated near the surface. In a square yard of mud flat one inch thick there are up to 90,000 of these animals. But these are not even the most abundant animals. Nematode worms are a thousand times more numerous, a fact you can appreciate by examining the mud with a microscope.

Marine creatures came to the delta about the time the islands were built. Adjacent to the mud flats, small channels are thick with the larvae and juveniles of shrimp, sea trout, gulf menhaden, striped mullet, croakers, and crabs. Some of the highest densities of larval fishes ever found in studies of estuarine nursery areas come from the quiet, protected back coves and mud flats of the Atchafalaya delta. Some of the fishes may have entered the delta by mistake, while searching for the brackish marshes that usually serve as their homes. Once at the delta, however

Lloyd Poissenot

they found no need to move on. The adjacent mud flats are a storehouse of food, and the channels between them are warm and too shallow for fish predators.

Other species, such as freshwater minnows and sunfish, were carried in by the floods. While most were flushed out to the gulf and probably perished, the lucky ones found a current that ended in a shallow cove. There they have remained, becoming part of the unlikely assemblage of freshwater and marine fishes that thrives in the delta.

Worms, roots, tubers, fish, crustaceans—this has to be some sort of island paradise for bigger animals, if they can find a way there. The most obvious animals in the area are birds. More than a hundred thousand ducks may be found at the delta on any given winter day. They are lured in by the land formations and food. The ducks here are primarily dabblers—mallards, blue- and green-winged teals, gadwalls, pintails, and widgeons—which find the shallow waters good for feeding. These ducks are primarily vegetarians in the winter and forage on arrowhead roots and rhizomes. They also eat other aquatic plants, and sometimes insects, fish, and mollusks.

Wading birds have relocated to the delta. Great blue herons are a rather common sight. We often see them patiently stalking fish in the shallow marshes. And in the evening, if we sit by one of the willow island rookeries, we can watch flocks of white and white-faced ibis returning from a day's foraging on the mud flats. Strung out in silent lines, they float by and then drop, one by one, onto the island. Other birds you see on the delta: tricolored and little blue herons, snowy and great egrets, roseate spoonbills, which hunt on the mud flats during the day and return to the islands at night to feed their young, and black-crowned and yellow-crowned night herons. The number of birds has increased dramatically in recent years. As late as 1978, no nests of wading birds had yet been reported. Now we guess there are 20,000 nests of wading birds.

Shore birds also stop in at the delta during their annual migrations—by the thousands. Dunlins and other small sandpipers are common. Dowitchers, with their long bills, probe the mud for food. Avocets sweep shallow pools of water with their long upturned bills, and plovers run across the mud, plucking organisms from the surface. These birds usually stay from October to March or April. Because the arrowheads have died back, exposing the marsh surface, invertebrate food is now more accessible.

With all these birds in residence, one might expect some interesting mammals, but there are few of them at the delta. We wonder about this every time we cut off the engine of our boat and glide into the muddy edge of a marsh. The island sings us a ravenous song of welcome—the disturbed buzz of billions of mosquitoes. We can wrap ourselves in plastic rain suits, but other mammals don't have such armor. Most likely, however, the treacherous swim to the delta islands, rather than the bugs, keeps them away. The only mammal here in any numbers is the nutria, a slow rodent that resembles a giant muskrat. Nutrias were accidentally introduced into southern Louisiana in 1938 and have spread into every aquatic habitat. We don't know when the first nutria came to the Atchafalaya marshes, but there are enough of them now to support a trapper. He and his wife live on a floating house barge during the winter and leave the area once the warm weather comes. Nutria fur is often sold as "simulated" mink.

Recognizing that the place taking shape at the end of the Atchafalaya River was unusual, the state of Louisiana in 1976 declared the delta and surrounding bay to be a special wildlife management area. But that may not be enough to protect it against the interfering hand of civilization.

Startled teals launch themselves from a shallow marsh on a delta island. Birds, especially ducks, are the most visible wildlife on the delta. The ducks eat the tubers of one of the first plants to take hold on the delta, the arrowhead. The willow- and arrowhead-covered upstream end of the island is in the background.

C.C. Lockwood

Roseate spoonbills are not very common in Louisiana, except in three or four places, including the Atchafalaya delta. They may have been drawn there by the abundant food supply and absence of predators. The number of spoonbill nests has expanded in recent years. Since 1973, when the first delta islands appeared, the number of wading bird nests has grown to 20,000.

Dan Guravich

The abundance of life seems reason enough to be concerned about it. But some people are watching the area for other reasons. They know that what is growing there is part of a long cycle of upstream river diversion and delta building by the Mississippi River and that the Mississippi is ready to begin a new phase in that cycle. But they are apprehensive about a river switch because nature's plan threatens many people living in south Louisiana.

If the Old River Control Structure were to fail during a flood, and the Mississippi changed course, the result could be disastrous. Floodwaters would leave about 140,000 people homeless in Morgan City and surrounding towns in the Atchafalaya's inland flood plain. Bridges, highways, power lines, and oil and gas pipelines would be destroyed, wreaking havoc in Louisiana and interrupting the flow of oil and gas to northern states.

Even if the course change didn't happen so violently, it would still have serious long-term consequences. When the Atchafalaya captures the flow of the river, Baton Rouge and New Orleans will lose their freshwater supply, now brought in by the Mississippi. A million and a half people, along with the multibillion-dollar petrochemical industry that lines the banks of the river, would be affected.

But the cost of maintaining the river in its present channel is also high. All the levees that have penned in the Mississippi, holding it on course, prevent the river from delivering sediment to the coastal marshes. The present Mississippi River delta and much of coastal Louisiana are experiencing the highest land loss in the United States, about fifty square miles of marsh each year. Should the trend continue, Louisiana within twenty-five years would lose an area equal to the state of Rhode Island. Furthermore, the levees force the river to grow straight out into the Gulf of Mexico, dumping its sediment into water 120 feet deep. Most of it is wasted at that depth; it would take years for any new land to be built.

As the eastern side of the Louisiana coast is disintegrating, new land is being built to the west. Even though the Atchafalaya carries only a third of the Mississippi's sediment, the effects go far beyond the small amount of land created in the bay. Beyond the delta, but still near the mouth of the river, sedimentation is reversing a century-old trend of marsh loss. The Atchafalaya delta only absorbs about two-thirds of the mud it receives. The rest is mainly carried west by prevailing currents. And currently that mud is rebuilding an area along the western Louisiana

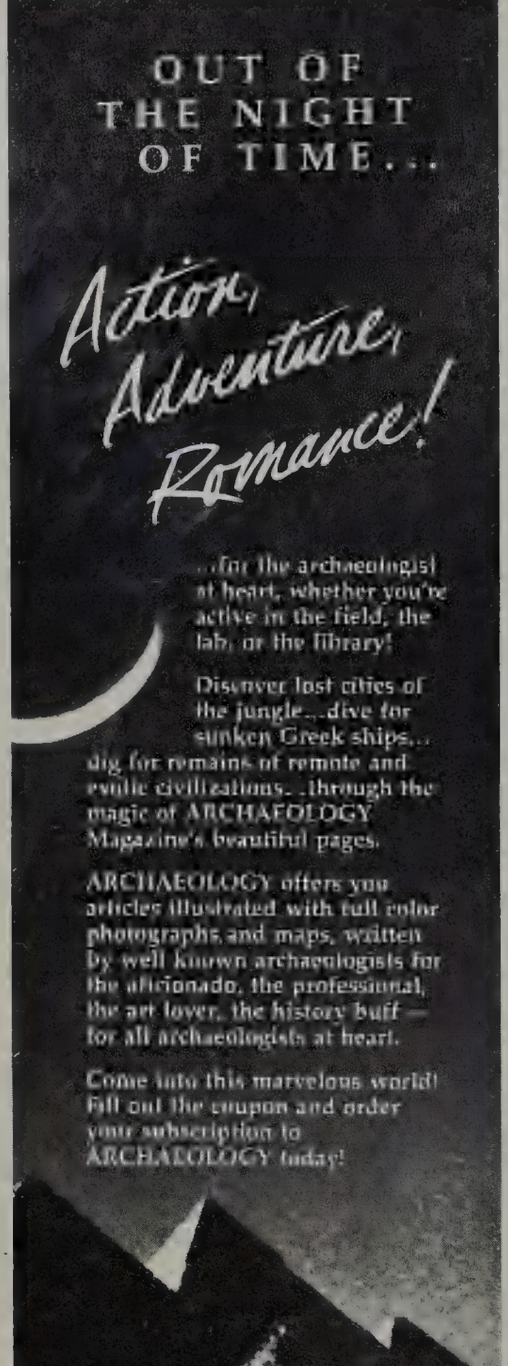
Willow trees cover a small island along the Atchafalaya River. Colonizers of wet areas, willows are prominent in the delta; their seeds are borne by wind.
C.C. Lockwood

coast called Chenier Plain, which until now has been one of the most rapidly retreating coastlines in the United States. But these long-lasting gains are often ignored in the clamor over the economic disruption that would be caused by a change in the Mississippi's course.

The battle between the Mississippi River and the Army Corps of Engineers continues, but nobody knows how long the humans can hold on. The official position of the corps is that the Mississippi can be contained indefinitely. Together with the Cajuns of south Louisiana, we are betting on the river. The flood of 1973 severely tested the Old River Control Structure and washed out one wing wall. To prevent the dam from collapsing, the corps had to dump thousands of tons of rubble into the hole dug by the river. Although construction of an ancillary control structure is nearing completion, ultimately, nature will have its way.

The Atchafalaya delta is different from the current Mississippi delta. For one thing, it is built in a shallow bay. Since less sediment is needed to build land in the shallow water, the Atchafalaya delta will grow more rapidly and eventually cover a wider area than the current Mississippi delta. In as little as a decade or perhaps up to a century, the series of separate islands now visible will merge together to form a broad expanse of fresh and brackish marsh, interwoven with shallow creeks and ponds. Clays and silts carried by the river will create another broad prodelta platform, like the one laid down before 1973. Another flood will trigger a new round of island growth and the fingers of the delta will reach farther, beyond the shell reefs that now form the seaward edge of Atchafalaya Bay.

The result of all this? A new coastline, with thousands of square miles of new land. It will be a spectacular land-building event, an incredible piece of work by an incredible river. But the Mississippi River has been doing this for thousands of years now, even in this same spot. For beneath the Atchafalaya delta are the remains of the Maringouin delta. This delta, as far as we know, was the great river's first delta, built more than 6,000 years ago. □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A Shattering of Stereotypes

by Sarah Blaffer Hrdy

FEMALE STRATEGIES, by Evelyn Shaw and Joan Darling, *Walker and Company, $14.95; 164 pp.*

Just about every woman biologist I know, either in amusement or in outrage, can rattle off her selection of "jacana tales." What? A jacana tale. One arises each time a researcher jumps to a wrong conclusion by assuming ahead of time how a male or female animal ought to be behaving.

Studies of the long-legged, lily-trotting birds known as jacanas provide classic examples of how sex stereotypes can cause us to misconstrue the natural world. For the jacana, like numerous other creatures, is what is known as a sex-reversed species (as though there were such a thing as sex normal). Male jacanas are smaller, more nurturing, and less aggressive than the females. The spindly little male dutifully cares for eggs deposited in his nest by females that travel between male nests, mating with as many males as they can manage, and fighting with other female jacanas for that privilege. Occasionally, female jacanas even destroy the eggs of competing females to gain more male attention for their own chicks. A fairly accurate accounting of jacanas has been on record for years, yet every so often one encounters in the pages of this or that scientific journal a vivid passage detailing the nest-tending antics of the female jacana, known to be the female, of course, because "Hey, look, she's the little one next to the nest!"

Evelyn Shaw, an eminent biologist known for her elegant studies of schooling fish and her many years as a dedicated teacher at Stanford University, has obviously encountered her share of jacana tales. Perhaps just one too many. For now, together with co-worker Joan Darling, she has written a book to set the record straight. *Female Strategies* reviews and celebrates the extraordinary diversity of a protean sex. Its primary goal, however, is "the shattering of stereotypes." "True," the authors concede, "females make eggs and males make sperm—for after all, that is how the two sexes are defined—but beyond this difference there are no universal axioms."

The shattering commences with Shaw's own specialty, small silvery perch that inhabit shallow waters along the Pacific Coast of North America. These are the shiner perch, which have turned out to be more promiscuous and far odder in their sexual habits than anyone could have dreamed possible. Even when her reproductive hormones are in low gear, with no ovulation going on, the female shiner perch is anything but sexually uninterested. Instead, she assertively courts and mates with as many males as she can with an abandon that, at first glance, appears to be sheer licentiousness, since she is in no condition to use the sperm. In fact, the female is stashing sperm in her ovaries, where they are stored, fed, and kept viable until she revs up endocrinologically for fresh egg production and in-house fertilization.

How are we to explain the behavior of this fish? First of all, we need to understand, as Shaw and Darling note wryly, that species such as these have not had the benefit of textbooks describing females as sexually "coy" and discriminating—textbooks that traditionally reserve the designation "promiscuous" for the male sex alone. Shaw and Darling suggest that the female shiner perch is taking out a form of

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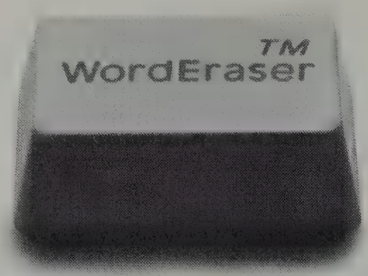

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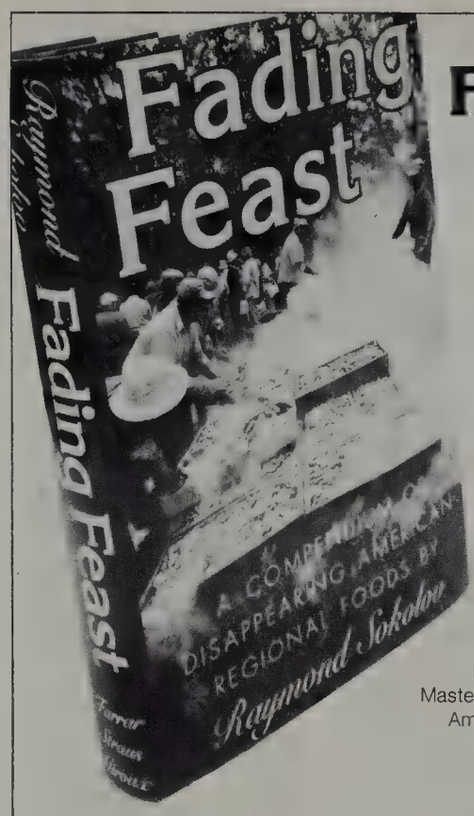
:netic insurance. By storing the sperm, e female has control over timing, and ith sperm from several fathers in tow, ıe has a backup should some gametes fail survive their ovarian interlude.

There are many possible reasons that males solicit multiple partners, but hatever the reason, all sorts of fish, sala-ıanders, butterflies, and garter snakes, as ell as most primates, turn out to be less ıan chaste. It has only been in the last :w years, with books such as this one (as ell as Meredith Small's *Female Pri-ıates* and Samuel K. Wasser's *The So-ial Behavior of Female Vertebrates*), ıat this sexually assertive facet of "femi-ine nature"—every bit as real as the ıuch mentioned "choosiness" of fe-ıales—is beginning to be discussed.

Female Strategies provides a fascinat-ıg sampler of what Shaw and Darling :rm the "liberated ladies of the animal ingdom." For starters, they turn to the :ores of invertebrates, fishes, and am-hibians that possess at birth the potential ɔ become either sex or even, in some ases, to be first one sex, then switch to the ther.

Consider the slipper shell, "a common eashore snail with the provocative name f *Crepidula fornicata*, so named because ıore than a dozen snails stacked on top of ach other live in permanent polygamous ınion. The big one on the bottom is always he female, and a male becomes a female vhen another slipper shell lands on top of t." Becoming a female, then, is purely a ɔositional matter. For the grouper fish, exual identity is even more slippery. Af-er shedding her eggs, this hermaphroditic ıum switches from the female to the ıale role and begins to spray sperm.

Shaw and Darling routinely combine ɔoetry with marine biology to carry us into he world beneath the sea. Into the depths ve dive, accompanying our authors as un-lerwater midwives to a female squid: 'There in the newly dark dusk and the irst glimmers of dawn, the female adver-ises her readiness to mate by projecting ıer squidy musks and exhibiting a coral-colored shell gland, easily seen through ıer translucent skin." She is attracted by 'ropy masses of squid eggs entwined with he algae on the sea floor," the sight of vhich serves as a massive aphrodisiac for ɔoth sexes. "The newly receptive female ıllows any nearby male to hug her in a ıany armed embrace." Thus held, she is ınseminated and released, not to lay strings of eggs, but to interweave them in a vast tapestry of eggs left by hundreds of ɔther mother squids, covering an area as arge as forty square feet. The resultant mass is so large and so complex that no



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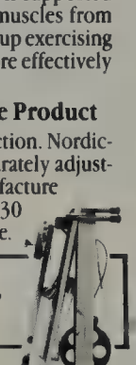

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predator can swallow it or even tear eggs free, and "the sea's currents would have a hard time uprooting this vast tumbleweed of the squid's next generation."

Such prose is the great success of this book, and I am in complete accord with the authors' main proposition that when we use the adjective *female* in its widest sense, we would do well to take nothing for granted. The stereotypes Shaw and Darling assault are all too real in the literature of evolutionary biology (though the detection of these stereotypes is perhaps not so recent nor so revolutionary with this book as the authors imply). The actual variety found in this most protean sex will exceed our wildest imaginings.

But there are undercurrents to this book that I find disturbing. As species after species is described, a new kind of double standard emerges, one for humans, for whom almost anything is possible, and another for nonhuman species, whose reproductive lives are governed by strict rules. Even the creature that changes sex does so in a totally predictable manner. "The females of every species but one live lives whose reproductive strategies are predetermined." I would argue, however, that the extraordinary degree to which reproductive strategies are situation-dependent has been greatly underestimated, especially for primates but also for other creatures. Even among some birds, such as dunnocks or acorn woodpeckers, and certainly among primates, such as the little mongoose lemur, one finds females that are monogamous in one context and polygamous in another. Some South American tamarins may be nonbreeding at one time and either monogamous or polyandrous at another, depending among other things, on ecological and historical circumstances. At the same time the notion that human possibilities are infinite strikes me as ideologically admirable but overly optimistic. And the authors do not really address such difficult questions as how biology affects and interacts with social construction of gender. Surely culture is not the only thing that separates a woman from a shiner perch?

Shaw and Darling celebrate the nearly infinite variety of species, venturing the hopeful speculation that "with a new understanding of the biological basis of femininity, can new cultural forms of femininity be far behind?" Such a passage merely underscores the point that the authors have really not given much thought to what nature's diversity actually means for women. Surely they are not suggesting that we take "nature's liberated ladies" as our templates? Just to carry this argument to an absurd extreme, consider the shine

erch. By the standards that most femi-
ists hold dear, this fish's behavior, with
er callous exploitation of captive sperm,
unethical, surely nothing to celebrate,
nly something to study and wonder at.
lthough I agree that the behavior of the
berated ladies can help destroy out-
noded and mistaken stereotypes in biol-
gy, I do not for a moment believe they
ill in any way serve women as useful
nodels. The book is naive on this score,
nd it is also naive in ignoring a women's
novement whose effects have been felt in
lmost every field, even biology. This
novement, and the powerful emerging
radition of feminist scholarship, made the
vriting, and certainly the publication of
his book in a popular form, possible. We
re deceiving ourselves if we imagine that
"more objective" modes of observation
an by themselves correct old biases.
Overlooked here is a subjective and ideo-
ogical intermediate step, and with it, the
otential for new bias. An awareness of
he existence of liberated ladies in nature
s part of an ongoing dialectical process,
ut not the last word on female natures.

One of the strong points of the book is
he incorporation of much rich material
rom marine biology into the debate on sex
differences. Some of the material from
ther fields, however, is less accurate. It is
rue that female baboons inherit their
anks from their mothers, but this makes
hem matrilineal, not "matriarchal"; no
matter which animal she inherits her rank
rom, a baboon female cannot dominate
ny fully adult male. Old World monkeys
re not, as stated, great apes. Langur
nales are not prevented from taking in-
ants; they virtually never try. Finally, to
ssume that our own ancestresses lost es-
rus to accommodate "husbands" as-
sumes that prehominid females had hus-
ands to begin with—something for
which there is not much evidence.

But these are quibbles and emenda-
ions. On the whole, this lovely book suc-
ceeds in its basic intent: shattering stereo-
ypes. For all those who still think jacana
emales are smaller, more passive, less
sexually assertive than males, the book
should be required reading, and for those
who still would assume out of hand that
he little bird tending the hatchlings laid
he eggs—perhaps even force-fed reading.
Even for those who already know a jacana
ale when they hear one, a pleasurable
eading experience is in store.

*Sarah Blaffer Hrdy is a professor of an-
hropology at the University of Califor-
nia, Davis. Her book* The Woman That Never Evolved *has recently appeared in
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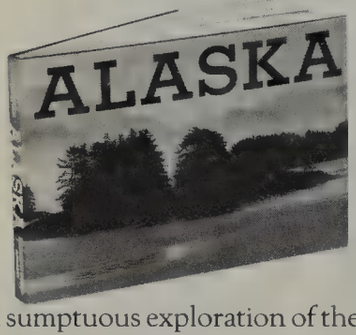

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Venus Aglow at Dawn

by Thomas D. Nicholson

Venus, west of the sun (to its right), rises first and climbs into the dawn sky before sunrise. Since it passed between the earth and the sun in early April, the planet has been moving steadily to the sun's right. As it turns more of its illuminated part toward the earth, Venus becomes brighter. In early June, it is virtually at its brightest, and by mid-month it reaches its greatest westerly elongation from the sun (measured to the sun's right). These two circumstances combine to make it a spectacular morning star in June. The only negative factor is that it will be far to the south, which keeps it low in the morning. But its brightness and early rising more than compensate for that.

While Venus is shining out in the east as dawn emerges, Jupiter dominates the south, rising before midnight. There is nothing in or near Capricornus to rival Jupiter's brightness as it moves down the western sky in the morning. Mercury, Mars, and Saturn are evening stars in June, but only Saturn can be seen during the entire night. It is up at dusk, in Libra, west (to the right) of Scorpius's bright reddish star, Antares, which rises about an hour later. Both Saturn and Antares move across the sky during the night and set at about dawn. The moon will help locate the two on June 1 and 2, and again at the end of the month. Mercury will be too close to the sun to be seen for most of June, but by the end of the month, it may be glimpsed low in the west just after sunset. Mars also will be lost in the sun's glare this month and hence difficult to view.

The following events are given in local time unless otherwise indicated.

June 1: Tonight's moon is at perigee (nearest the earth) and close to Saturn, in Libra. The planet is above the moon; the reddish star to the east (left) is Antares.

June 2: Full moon is at 10:50 P.M., EST. Antares can be seen dimly through the scattered light below the moon, and Saturn is well to their right.

June 4: The moon rises (about 9:00 P.M., EST) in Sagittarius.

June 7: Mercury is at superior conjunction, passing the sun from right to left and entering the evening sky.

June 7–8: The waning gibbous moon rises with Jupiter at about midnight, moving slowly to the left beneath the bright planet as both climb the morning sky.

June 10: Last-quarter moon is at 3:19 A.M., EST.

June 12: Venus is now forty-six degrees to the sun's right, its greatest westerly elongation during this cycle. Still close to maximum brilliancy, the planet is a very prominent object in the southeast at dawn, bright enough to be seen in daylight. The best daytime view is during the late morning, when Venus is to the west of the meridian (an invisible line that divides the eastern half of the sky from the western half) and at about the same height as the sun.

June 13: Apogee moon, in Aries.

June 14: If you get up early enough, you can see brilliant Venus, just below the crescent moon this morning.

June 15: The earliest sunrise of the year occurs in the Northern Hemisphere today. Latest sunset is on June 27.

June 18: New moon, at 6:58 A.M., EST, is in Taurus, near Mars.

June 21: The sun is at the summer solstice today, the position along the ecliptic in the constellation Gemini where it is farthest north of the earth's equator. Summer begins in the Northern Hemisphere at 5:44 A.M., EST, and the sun is above the

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horizon for the longest duration of the year. The thin crescent moon should be visible tonight for the first time since the new moon.

June 22: The moon is in Leo. Below the crescent is Regulus, brightest star in Leo.

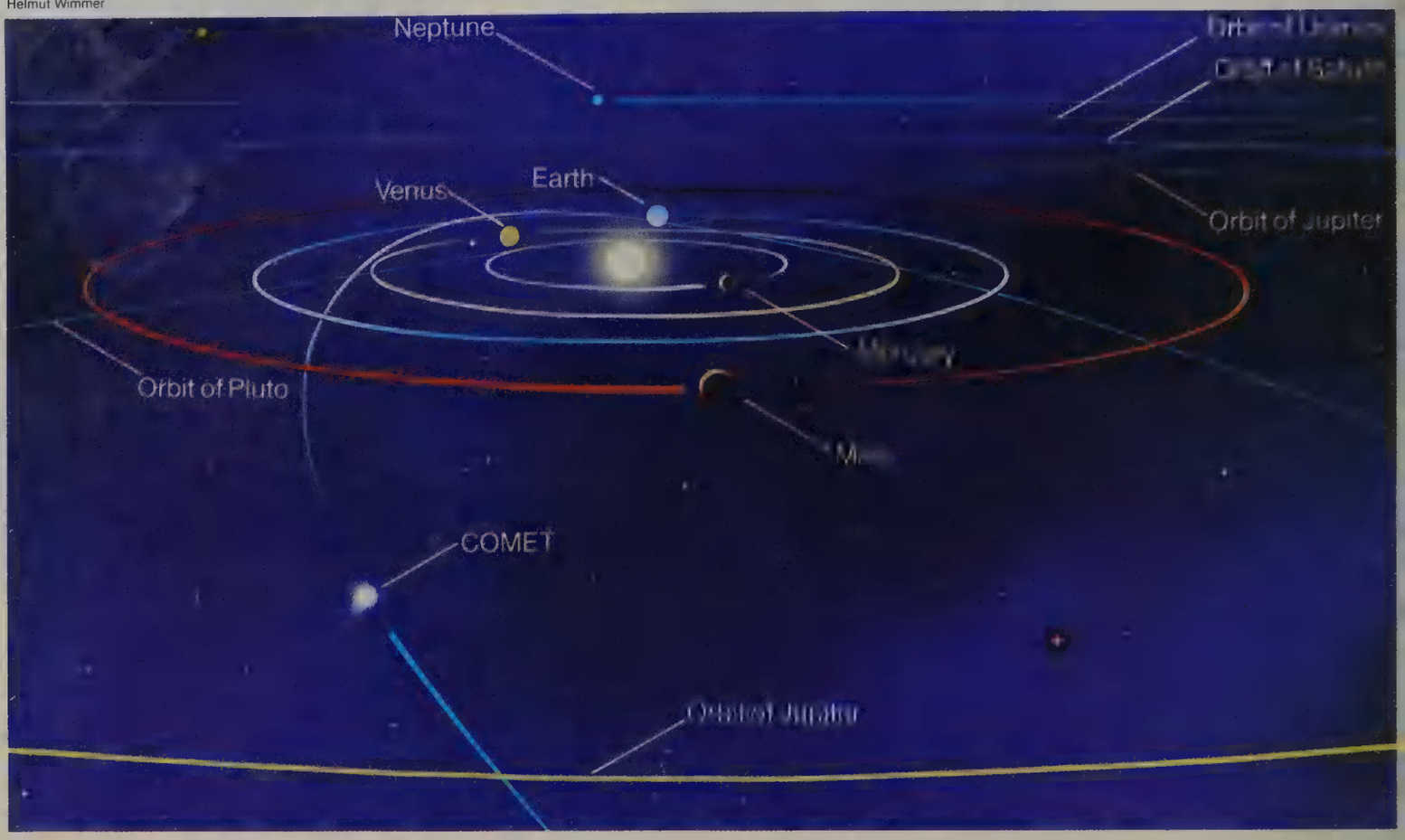
June 25: The moon passed above the autumnal equinox, in Virgo, earlier today, and it reaches first-quarter phase a few hours later, at 1:53 P.M., EST.

June 26: The star just below the moon is Spica, in Virgo.

June 28–29: Watch the moon drift easterly beneath Saturn on the evening of the 28th. It is at perigee on the morning of the 29th.

June 30: The waxing gibbous moon, two days before full, is passing through Ophiuchus. Antares, in Scorpius, to its right, and Saturn, farther right, are virtually in line with the moon.

Helmut Wimmer



Halley's Comeback

The earliest evidence that the forthcoming visit of Halley's comet to the earth's sky is on schedule emerged several years ago. Although the comet wasn't actually seen or photographed then, its presence and location were confirmed by an analysis of radiation in the region. Obviously, this is nothing like the pre-perihelion search during the comet's last appearance, in 1910, when astronomical equipment, materials, and techniques were much less developed. The first sightings then (actually photographs) weren't made until August 1909, eight months before the comet's closest approach to the sun in April 1910.

Because of today's advances in astronomical detection, photographs of the comet's approach this year have been available for some time, though they show nothing but a faint, starlike image drifting slowly through distant stars. Visual sightings were reported as early as February of this year but may not be repeated reliably until this month, and then by dedicated comet watchers with suitable equipment. Still, I wouldn't recommend your rushing out to buy a telescope just yet, no matter how much you may wish to see the comet. As a matter of fact, you may not need a telescope at all.

But given the poor conditions expected during the comet's visit this year and next, you may very well need some optical equipment to improve your chances of seeing it. The most useful equipment for seeing Halley's comet may be a pair of binoculars—not a telescope. With their wide field of view, binoculars let you search more easily and see more of the comet in its field than a telescope would. They are ideal for finding and studying a dim, extended object in the sky. Try them out with the Milky Way, for example, and you will discover that it looks better through binoculars than with a telescope.

A fine instrument for comet viewing is a pair of 7 × 50 prism binoculars. The number 7 is the magnification, low—but you don't need a lot of enlargement. The number 50 is the diameter of each objective, or front lens (about twenty-five millimeters equal one inch), large for good night vision. Prism binoculars (in which the light follows a path through several prisms between the objective lens and the eyepiece) provide a more compact instrument and yield an image that is right side up. The comet should be bright enough to be seen with a pair of 7 × 50 binoculars beginning in late November or early December 1985.

This month's Comet Halley "road map" of the solar system shows the object still crossing the vast space between the orbits of Jupiter and Mars. Remember, of course, that the comet is still several million miles south of those orbits on its own inclined cometary path.

You can get some idea of the vast distances separating the planets in our solar system by noting how long it is taking for the comet to move within the orbit of Mars. It passed inside Jupiter's orbit in January, but won't come within Mars's orbit until the end of November. And this despite its speed of about 43,000 miles per hour at its present position. In mid-June the comet is about 338 million miles from the sun and about 432 million miles from the earth. After entering our morning sky in late May, Halley's comet again moves closer to the earth.

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Everyman's Muffins

The scones that are the specialty of Salt Lake City appear to be the only bona fide regional food of Utah

by Raymond Sokolov

I would have liked to include a few scone recipes in this chapter, but once you start on scones where do you stop?

Elizabeth David,
English Bread and Yeast Cookery

Like me, most of you probably grew up thinking of scones as rich muffins. My mother used to bake small circular ones when I was growing up in Detroit. Later, when I lived in England, I ran into similar buns at teahouses.

That was twenty years ago, and I hadn't given scones a second thought until I was recently preparing for a visit to Salt Lake City and noticed in Michael and Jane Stern's *Good Food* that scones were a specialty of the city. This seemed odd, and when I read the Sterns' description of Utah scones, I was sure they were not the scones I had known elsewhere.

Michael Stern was as puzzled as I was. Salt Lake scones were most unsconelike, he told me on the phone before I left: they were fried, puffy, and sometimes split and used as buns for sloppy Joes.

This was confusing but exciting news. Salt Lake is not a rich area for gastronomic research. The Mormons, who settled the city and whose culture is surely still the dominant local strain, were (and are) a religious group drawn from many traditional cultures, not an ethnically coherent population with a settled food tradition. Mormons are zealous missionaries who proselytize among nearby heathen, notably American Indians, and all over the world. This international outlook led them to develop their own script and lingua franca, Deseret. But on the culinary level, they seem to have been content to continue the diet the first Mormons brought with them in the second half of the nineteenth century. Since the early settlers departed from the Midwest, it isn't surprising that today's typical Mormon food should closely resemble midwestern farmhouse food.

In Salt Lake, I was able to verify this assumption at the Mormon world's closest approximation to an official restaurant, a cafeteria called the Pantry, situated in the Lion House, a former home of Mormon patriarch Brigham Young. The building is not open to the public but serves the Mormon community as a sort of banquet hall and dining club. No fewer than five wedding parties were celebrating the day I was taken there.

From years of such prominence in Mormon feasting, the Lion House kitchen has taken on a special luster among the faithful. Reservations for the banquet rooms are said to be made years in advance. It seems reasonable to say, then, that the kitchen of the Lion House represents Mormon traditional cooking at its best. And judging by what I ate at the Pantry and by the recipes collected in 1980 for *Lion House Recipes,* Mormon cooking is an unreconstructed expression of mainstream middle American food: jello salads, pies, meat and potatoes.

Lion House Recipes does contain some relatively exotic dishes, such as Greek salad and Mexican taco salad. What it lacks almost completely is purely local food ideas not imported from somewhere else. It would be unfair, however, to blame the lack of purely Utah recipes only on the Mormons. You will find almost no bona fide regional recipes in the secular counterpart to *Lion House Recipes,* a compilation entitled *What's Cooking in Utah Kitchens,* edited by Donna Lou Morgan, food editor of the *Salt Lake Tribune.*

There are, to be sure, original dishes, such as Chicken Porter Rockwell (a chicken pie), and various other concoctions culled from family recipe files, but the only dish in either of these books that seems to have developed in Utah and taken root in the regional culture is the anomalous fried bread called scone.

In Utah, by the evidence of both local cookbooks and three local restaurants, the scone starts out as a yeast-raised, sweet dough that is cut into 2-by-2-inch squares (or other shapes of similar surface area) and deep-fried. The most popular method of service is with butter and honey. That is how I ate a midmorning scone at Johanna's Kitchen in a mall at Jordan, Utah. They didn't bother to bring honey at the Pepper Tree in Salt Lake, but they did advertise a free scone with each breakfast "entrée" on the sign out front.

Clearly, the Utah scone is not a vanishing bread. Certainly not at the two-restaurant chain in Salt Lake City called Sconecutter. At these twenty-four-hour drive-ins, the Utah scone rises to challenge the doughnut and the hamburger bun as a fast-food commodity. Cooked on the spot from yeast dough, the scones come out crisp, puffy, and rectangular. The dough inside is airy and pleasantly chewy. But are they scones in the normal sense? And if not, where do they come from? How did they start?

Traditional English scones are too diverse to classify with much certainty, as Elizabeth David warns us. But they do generally qualify as muffinish quick breads, and mostly they are baked. According to the Oxford English Dictionary, scones (derived from the Middle Low German *schonbrot,* or fine bread) are baked, cooked on a griddle stone, or even fried (but not deep-fried). Yeast does crop up sometimes, for example, in Jane Grigson's recipe for Northumbrian wholemeal scones in *English Food.* But no traditional British scone I have ever eaten or read about comes close to resembling the Utah scone. So it seems improbable that early Mormons of British extraction imported the deep-fried scone to their New World Zion.

When I asked her about it, Donna Lou Morgan guessed that pioneer Utah cooks, who were inveterate bread bakers, had taken to frying some of the yeast dough they often had on hand. She remembered her own mother pinching off pieces of bread dough and frying them, but Morgan's own recipe for scones, which is very much like the Lion House's, is not based on a conventional bread dough. It is richer and sweeter and has chemical raising agents in it, undoubtedly to boost the puffing of the scone as it fries.

The first time I ate a Utah scone, I was certainly not reminded of bread or of traditional muffin scones. I thought instantly of two other puffy fried breads popular in

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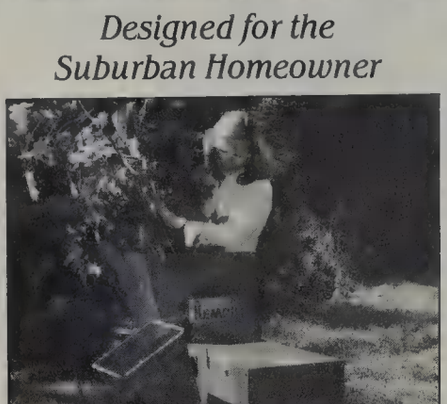

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the West: Navajo fry bread and New Mexican sopaipillas (see recipes). The taste of both these regional "breads" is very close to the taste of Utah scones. Yes, the shapes and textures vary a little. But with the sopaipilla, there is an extra link. Like Utah scones, sopaipillas are served with honey.

Until some researcher makes a lucky strike in a Mormon woman's diary or a pioneer cookbook, we are never going to know for sure how it is that Navajos, Chicanos, and Mormons ended up eating similar fried breads. It could all be coincidence, but in the absence of hard facts, it is tempting to construct an explanatory scenario that will connect all the fried breads so popular in the mountain time zone, from Bountiful, Utah, to Hatch, New Mexico. Here is one.

Let us suppose that both the Navajo fry bread and the sopaipilla predate the Utah scone. They are simpler and history is on their side. Both Navajos and Hispanicized New Mexicans were in their present regions long before the Mormons. Their fry breads are almost identical, and so it makes sense to look for an archetypal southwestern fry bread from which both descend. Now since most culinary ideas in the U.S. Southwest moved there from the south, when Mexico controlled the area there ought to be a Mexican ancestor for the sopaipilla and for the Navajo fry bread.

In fact, there is one. Diana Kennedy located sopaipillas in the Mexican state of Chihuahua, which shares some of its northern border with New Mexico. Sopaipillas are uncommon there, but they are called sopaipillas and are similar to those eaten in New Mexico, except that in Chihuahua they aren't made with a chemical raising agent (or with yeast). This greater simplicity argues in favor of Chihuahua as the birthplace of American fry bread.

Still, it may be that the Chihuahuan sopaipilla is a later simplification of a New Mexican original. But I doubt that. Common sense tells me that the baking soda now used by Navajos and Chicanos came to them at a late date from the intruding Anglo world. The primitive fry bread now preserved in Chihuahua was probably once indigenous to the entire region we are talking about and now survives only in Chihuahua because of its remoteness from outside influences. Most probably then, when Mormons first came into contact with southwestern Indians, the

Buttermilk Scones

(Slightly adapted from *Lion House Recipes,* compiled by Helen Thackeray, Shadow Mountain, P.O. Box 30178, Salt Lake City, Utah 84130, $9.95)

- 1 quart buttermilk
- 2 packages (2 tablespoons) dry active yeast
- ¼ cup sugar
- 2 eggs, beaten
- 2 tablespoons oil
- 1½ teaspoons salt
- 1 tablespoon baking powder
- 1 teaspoon baking soda
- 8 cups flour
- Oil for frying

1. Heat buttermilk until warm.
2. Meanwhile, soften yeast in ¼ cup lukewarm water.
3. In a large bowl, combine buttermilk, sugar, eggs, oil, salt, baking powder, baking soda, and 4 cups flour. Add yeast. Beat until smooth. Add remaining flour to make soft dough. Allow to rise, covered, until doubled in bulk. Punch down and place in refrigerator overnight.
4. When ready to fry, heat oil to 375 degrees. Roll dough out on a floured board until ¼ inch thick. Cut into 2-by-2-inch squares.
5. Fry a few scones at a time. Stretch out each piece a little before frying and drop into hot oil. Fry on one side until golden; turn with tongs and fry on other side. Drain on paper towels. Serve hot with honey and butter.

Yield: 60–100 scones, depending on size of squares

Note: The dough will keep in the refrigerator for 3 to 4 days. Keep punching down and cover tightly with foil or a damp cloth.

Indian Fry Bread

(Slightly adapted from *American Indian Food and Lore,* by Carolyn Niethammer, Collier)

- 4 cups flour (all white or ½ white and ½ whole wheat)
- 1 tablespoon baking powder
- 1½ teaspoons salt
- 1½ teaspoons cooking oil

1. Mix the flour, baking powder, and salt. Add oil and enough water to make a soft dough. Knead with a floured hand until the dough has some spring. Shape into balls about 3 inches in diameter. Pat each ball into a flat cake and keep patting and stretching the dough into a thin sheet, 10 to 12 inches in diameter. This takes practice.
2. Fry each round in very hot fat, turning once, until golden and puffy.

Yield: 12–14 bread puffs

und them eating an unleavened fried ead that puffed up in hot oil.

Inevitably, they tasted it and liked it. ormon women then tried to duplicate e recipe and added a whole battery of sing agents they knew about from Eng- h baking. They put in buttermilk be- use its mild acidity was necessary to ac- ate baking soda and make it give off rbon dioxide. They added eggs and gar and ended up with a delicious and ginal bread, related in kind to the *ignet* family, but a thing unto itself. And cking a name for the thing, they remem- red scones, quick sweet breads from ck home that were also cut into individ- l serving pieces before cooking.

This is only a hypothesis, not a substi- te for real evidence. At any rate, the ah scone flourishes on its native ground, rd by its Indian cousins. And no matter w Navajo bread, sopaipillas, and Utah ones actually came about, it is the case at the Four Corners, where Utah, Ari- na, New Mexico, and Colorado meet, is e fried bread capital of the world.

aymond Sokolov is a writer whose spe- l interest is the history and preparation food.

Sopaipillas

Adapted from *The Feast of Santa Fe,* Huntley Dent, Simon and Schuster)

1 cup plus 2 tablespoons flour
1 teaspoon baking powder
¼ teaspoon salt
2 tablespoons lard or vegetable shortening
Oil for deep frying

Combine the flour, baking powder, and salt in a mixing bowl.

Cut the lard or shortening into the flour mixture until flaky.

Pour in ¼ cup plus two tablespoons water all at once and mix quickly with a fork to make a sticky dough.

Flour a board and turn the dough out on it. Knead 10 to 12 times, until dough is no longer sticky. Cover with plastic wrap and let rest 15 minutes.

Roll out half the dough to a 10-by-5-inch rectangle. Cut into two 5-by-5-inch squares (or into smaller squares or triangles if desired).

Heat oil to 400 degrees.

Fry one square at a time. Drop into oil and hold submerged with a metal spatula until it puffs. Release, let brown, and then cook on other side until browned. Drain and serve or keep warm in a 200-degree oven.

Repeat with other half of dough.

Yield: 8 small or 4 large sopaipillas

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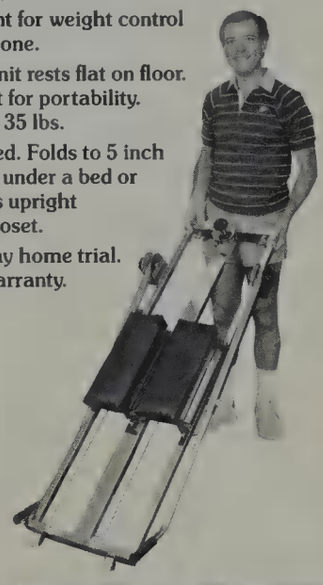

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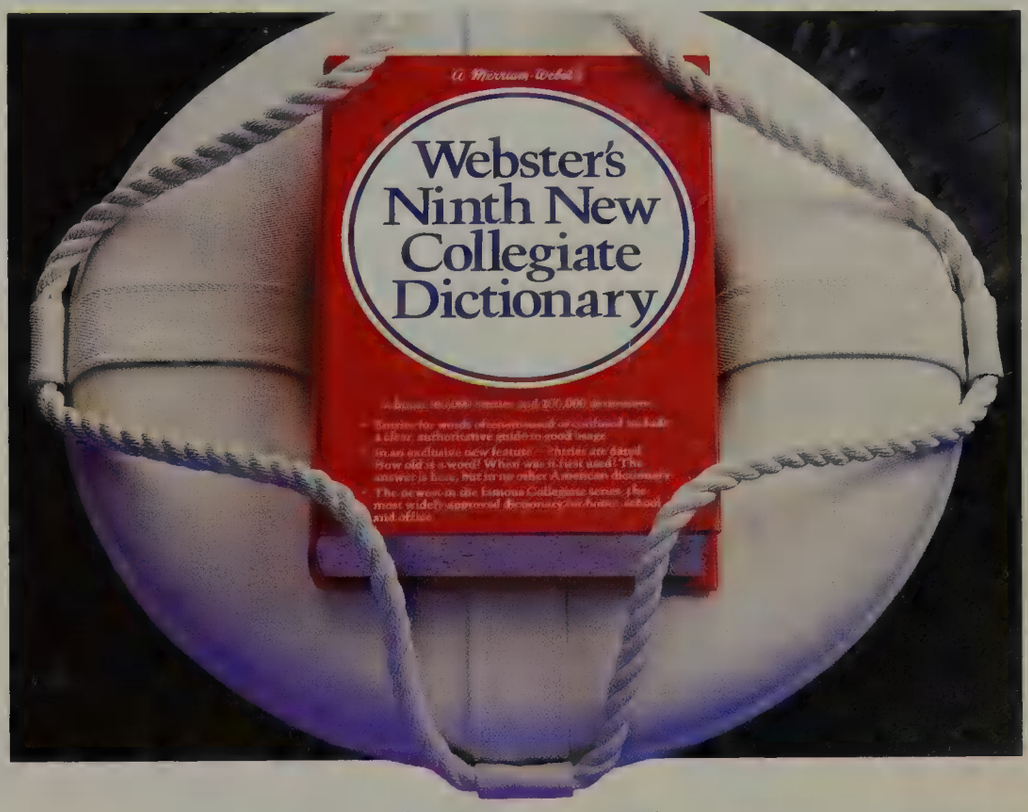

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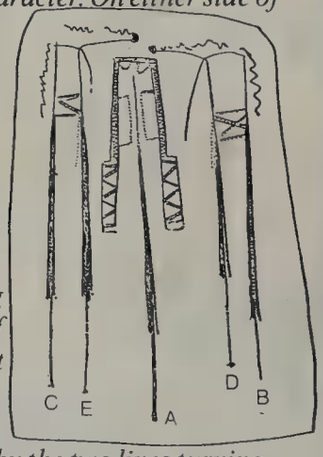
From Siberia with Love

One of the rarest and most obscure artifacts in the Gardner D. Stout Hall of Asian Peoples is a small scrap of birch bark, with a red ribbon tied to one end, covered with incised geometrical designs. This scrap is actually a letter—a love letter—written by two girls of the Yukagir (formerly Yukaghir) tribe, a small group of people who once lived in northeastern Siberia near the shores of the Arctic Sea. The letter, which was directed to the anthropologist who was studying the tribe, is written in a pictographic language that is similar to an early stage in the development of our own alphabetic system and may hold important clues to the development of writing in general. It is believed to be the only genuine Yukagir love letter in existence, although a number of copies can be seen in Leningrad.

The letter is an unusual example of the misunderstandings that can sometimes arise between anthropologists and the people they are studying. (New insights and information can often spring from such misunderstandings.) It was given to the Museum by Waldemar Jochelson, a Russian ethnologist, who spent many years living among the remote tribes of Siberia. The letter had remained in an anthropology storeroom for nearly eighty years when it was "rediscovered" by Cynthia Wilder, an assistant in the Anthropology Department, during preparation for the Hall of Asian Peoples.

Jochelson came to study Siberian tribes almost by accident. He had been exiled to Siberia by the czar because of his revolutionary activities. Once in Siberia, how-



In this Yukagir love letter, written to anthropologist Waldemar Jochelson, people are represented by thin decorated lines. Jochelson (a) is depicted standing in front of his house. He occupies a position of status, as evidenced by the height of the character. On either side of him (e and d) appear the two jilted Yukagir girls. Both send passionate thoughts to him—shown as the two faint lines emanating from the tops of their heads. But Jochelson rejects their love, indicated by the two lines turning back in a series of squiggles. The two figures on the far left and right (c and b) are Jochelson's interpreter, Alexander Dolganoff, and the Cossack guide. The two girls point out that they achieved more satisfying relationships with them. One relationship is strong, indicated by the X between the two characters; the other is more casual, represented by the backward Z between them.

Lee Boltin, collection of AMNH

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ever, he was allowed to travel and work, although at times he was shadowed and harassed by the czar's secret police. To put his exile to good use, he began doing geographical and ethnological fieldwork for the Imperial Russian Geographical Society in 1895.

In 1897, Franz Boas, then an assistant curator at the American Museum, heard about Jochelson's work through the Russian Academy of Sciences. In an effort to prove the theory that the American Indian had originally migrated from Asia to North America by crossing the Bering Strait, Boas began organizing an expedition to gather information about the tribes living along the rim of the North Pacific Ocean, from Washington State to Alaska, Siberia, northern China, and Japan. Because of Jochelson's previous work with Siberian tribes and his fluency in both Russian and German, Boas hired him and his wife, Dina Brodsky Jochelson, to conduct research among the Yukagir, Tungus, Koryak, and other remote Siberian tribes. Boas instructed them to collect everything they could—including artifacts, myths, photographs, dictionaries, grammars, wax-cylinder recordings of songs, anthropometric measurements, bones, and graveposts. He also purchased some of Jochelson's earlier collections, including those made among the Yukagir on his first trip in 1895–96.

Boas saw the fragile aboriginal cultures of the North Pacific rim poised at the edge of extinction. In many ways what was happening in Siberia was a mirror image of what was happening in the American West—and Boas knew that in both cases the results would be tragic. His overriding desire, shared by Jochelson, was to save every possible thing related to these societies for future study and, ultimately, the common heritage of humanity.

Of all the tribes Jochelson studied in Siberia, he felt a particular fondness for the Yukagir. Jochelson saw them as a mild-mannered people who believed in honesty, kindness, and hospitality and abhorred rudeness, foul language, and personal violence. These qualities resulted in their being exploited and abused by the Cossacks, by Russian settlers, and especially by the local priests and contributed, Jochelson felt, to the rapid decline and assimilation of Yukagir culture.

The love letter is one of thousands of artifacts Jochelson saved from the Yukagir, some of which are on display in the Siberian section of the Hall of Asian Peoples. The history of the love letter is curious

At the American Museum

Identification Day

Once again, the Museum will hold its popular *Identification Day.* On June 1, visitors can bring in their unknown rocks, shells, fossils, insects, pottery, artifacts, and just about anything else—except for gemstones—to Museum scientists, who will do their best to identify them. The program, which will run from 1:00 to 5:00 P.M. in the Dana Education Wing, is free to all Museum visitors.

Cruise Around Manhattan

On Tuesday, June 4, from 5:30 to 8:30 P.M., geologist Sidney Horenstein will host a three-hour, twilight boat trip around Manhattan to survey the unusual geology of the island and the surrounding Palisades. The Hudson is North America's most southerly fiord, and its geology is unique along the Eastern Seaboard. Cost of the trip is $18 for members, $20 for nonmembers. Contact the Education Department for more details.

Cruise into New York Bay

On this three-hour cruise around New York Bay, participants will view forts from the War of 1812, the glacial moraine that is Brooklyn, and learn the origin of the Narrows under the Verrazano Bridge. Sidney Horenstein will lead this unusual tour of the geology, flora, fauna, and history of the Upper Bay area. It will take place on Tuesday, June 11, from 5:30 to 8:30 P.M. Cost is $18 for members, $20 for nonmembers; contact the Education Department for details.

Queen of Heaven

The Membership Office will present *Inanna: Queen of Heaven and Earth* on Friday, June 7, at 8:00 P.M. in the Kaufmann Theater. The story of the goddess Inanna's life was recorded 4,000 years ago on clay tablets and wall murals from Sumer and Babylon. Storyteller Diane Wolkstein will recount the saga of Inanna; Geoffrey Gordon will provide musical accompaniment. Tickets are $8 for members and $10 for nonmembers; for more information call (212) 873-1327.

Bobcats and Bobkittens

This month's *Members' Family Program* will focus on the bobcat. Hope Ryden will show slides of this elusive animal and talk about its life cycle, behavior, and range, as well as current efforts to save it from fur hunters and habitat destruction. The free program, open only to members, will take place on Tuesday, June 25, at 7:30 P.M. in the Auditorium. Tickets are required.

chelson received it during his first stay h the Yukagir in 1895–96, shortly after was exiled to Siberia. He had two comnions on this trip, a Yukagir interpreter med Alexander Dolganoff and a Cosk guide.

While the Yukagir frowned on immody and were very bashful in discussing xual matters, there was considerable edom in relations between the sexes. rginity was not important to the Yuka-, and most girls set up their own tents at berty and quietly began receiving lov-. One custom in Yukagir society was to ovide an unmarried girl to any man who s away from his wife. A father would rmally offer his daughter's bed to a visng man as a courtesy. If the man was imrtant, the daughter would consider it an nor to share her bed with him. However, was completely up to the girl whether e had sex with the man. If she found him jectionable, she was perfectly free to eave her loin cloth on" (according to a ukagir proverb).

Jochelson spent his first four months nong the Yukagir learning their lanage in the house of a tribal elder who ed near the Yassachna River. The elder d his wife had an adopted daughter of out seventeen or eighteen years of age. s soon as Jochelson settled in, he noticed at the usual nightly visits of young men the girl had ceased. After a while the fe of the elder seemed puzzled by chelson's sexual abstinence. She said, t seems that among you, men can live thout wives." Jochelson explained that here he came from, a married man was pposed to remain faithful to his wife, en when he was away for a long time. ccording to Jochelson, the woman reied, "Well, it seems that the Russians re have different customs. They go to her girls and wives, even when they have eir own wives with them." Later, his inrpreter told him that the elder's adopted ughter was very offended that Jochelon had not visited her, as was the custom r a male guest in her parents' house.

That summer, at a camp near the Yaschna River, a similar misunderstanding curred. "In this village," Jochelson rote,

ved the blacksmith Shaluguin, an old ukaghir, who had a large family, among em several daughters. The youngest was nsidered to be the prettiest on the river assachna. For a long time I intended to ke her photograph in holiday dress, and eant to do it before my departure; but, as e was then staying with her relatives in nother settlement, I asked the old man to nd a boat for her. In spite of the fact that I xplained to the old man what I wanted his daughter for, my request was understood in another way. The girl arrived late in the evening, and I put off taking the photograph till the next morning. My canvas tent was standing near the skin tent of Shaluguin. Imagine my astonishment next morning when, stepping out of my tent, I noticed between it and that of Shaluguin a separate small tent, which the girl was just then taking away! She was in a very angry mood, and my photographs were not successful. Afterwards my interpreter told me that the young men laughed at the girl for having uselessly put up a separate tent.

When Jochelson left the Yassachna River, the two spurned Yukagir girls wrote him the love letter. It told the story of their frustrated romance with the anthropologist and, according to Jochelson, was given to him with no trace of jealousy or bad feeling.

Jochelson kept this letter in his personal collection and later was not able to locate any similar examples. In 1901 and 1902, when he returned to the Yukagir on a trip sponsored by the American Museum, drastic changes had taken place. The tribe had been decimated by disease and starvation, and Jochelson spent much of his time trying to get medical supplies, food, and assistance to them. In the face of this overwhelming change and misfortune, the Yukagir had abandoned a number of traditional customs, including, it seems, the practice of writing love letters. In his ethnography, *The Yukaghir,* published by the Museum in 1910, Jochelson speculated on the future of the tribe:

> The Yukaghir, who in the past, according to all collected information, were a fairly numerous tribe, at the present time consist . . . of a few hundred people scattered in small groups over an enormous area, which groups are dying out rapidly. . . . This tribe is therefore on the verge of complete physical and ethnic extinction.
>
> The study of a tribe . . . insignificant in numbers and having no future—was a difficult, and, from a practical point of view, a thankless task. But the science of ethnology recognizes that a knowledge of small tribes is equally as important as that of great peoples. In fact . . . information about the life and history of a tribe which is becoming extinct is particularly important.

The birch bark love letter is just one of eight million artifacts in the Museum's anthropology collections. These artifacts, however, are not merely a collection of inert objects; each was once very important to the person who created it and owned it. Like the Siberian love letter, each one carries with it a trail of history, of information, and of meaning.

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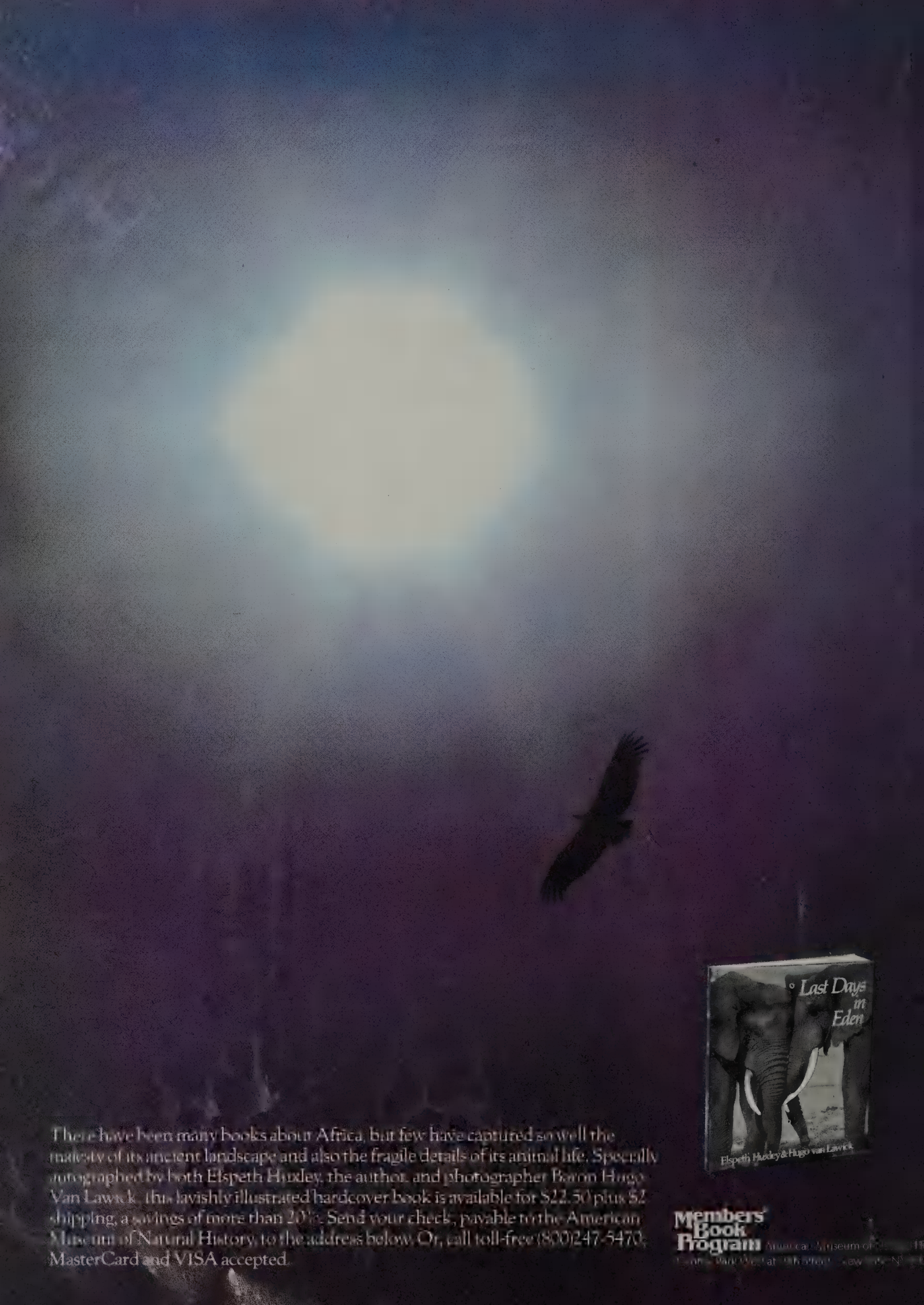

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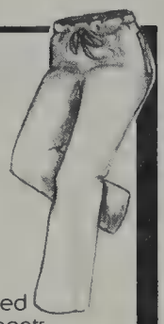

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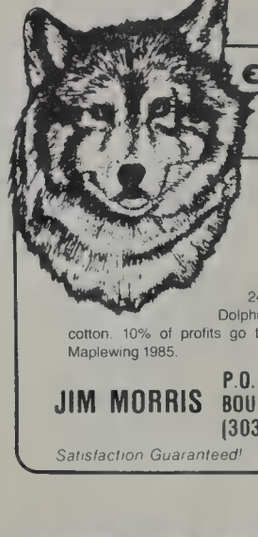
A Sealed Fate

Driving along California's coastal highway last year, Peggy and Erwin Bauer passed the place where the Russian River joins the ocean. There, they noticed quite a few harbor seals lying on a sand bar that had been exposed at low tide. The Bauers decided to investigate this scene. After a steep descent, they arrived at the sand bar and found about forty seals hauled out on the sand. Others were swimming nearby. At that point, an eel jumped out of the river and thrashed helplessly on the bank. A harbor seal climbed out after it and, taking the prey in its mouth, slid back into the river to devour it. As the Bauers watched, more and more eels began to pop out of the water along a fifty-yard stretch of river immediately upstream. Each was pursued, caught, and eaten as before. After observing and photographing this foraging behavior for some time, the Bauers realized what was happening. The seals were chasing the eels into the shallow areas at the edge of the river and then forcing them out.

The Bauers had never seen such behavior before but, quite possibly, no one else has either. According to Jake Houck, a marine mammalogist at Humboldt State University in California, seals are not known to prey on eels this way. "If they were eels, they would have to be lampreys," Houck says. "I don't doubt the report is correct. But I have never heard of anyone reporting seals chasing eels out of the water that way."

Houck points out, however, that harbor seals are opportunistic feeders that will take any food item that appears in abundance in their environment, including octopus and salmon. Why were so many eels passing through the area? "They were probably making an upstream spawning run," Houck says. "The eels are at the end of their life cycle. They are looking for gravelly areas where they will spawn and die."

Photograph by Peggy and Erwin Bauer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Additional Reading

Underwater Pollination (p. 36)

Paul Alan Cox's "Spore Theory, Random Motion, and the Convergent Evolution of Pollen and Spore Morphology in Aquatic Plants" (*American Naturalist,* vol. 121, pp. 9–31) considers the nature of random motions and the theory of random search, which suggests that search efficiencies would be much greater for aquatic spores that have large, long axes and move in planes (such as water surfaces) rather than in three dimensions. Sea grasses flower underwater, shedding pollen that is borne from plant to plant by waves. John Pettitt, Sophie Ducker, and Bruce Knox explore the differences between the sea grass system of reproduction and that of land-based plants in "Submarine Pollination" (*Scientific American,* March 1981, pp. 134–43). C.T. Ingold's *Spore Liberation* (Oxford: Clarendon Press, 1965) explicates fungal spore dispersal and is abundantly illustrated. A number of general books on pollination explain how it occurs underwater; these include Michael Proctor and Peter Yeo's *The Pollination of Flowers* (New York: Taplinger, 1973) and K. Faegri and L. van der Pijl's *The Principles of Pollination Ecology* (New York: Pergamon, 1972).

Derelict Ships (p. 42)

Henry Stommel, the oceanographer who did most of the basic theoretical work on the wind-driven circulation of the Gulf Stream, wrote one of the best books on the current: *The Gulf Stream: A Physical and Dynamical Description* (Berkeley: University of California Press, 1965). In honor of Stommel's sixtieth birthday in 1981, the MIT Press, Cambridge, published *Evolution of Physical Oceanography,* edited by Bruce A. Warren and Carl Wunsch (Cambridge: The MIT Press, 1981). One chapter, by Nick Fonofoff, updates Stommel's data on the Gulf Stream. L. Valentine Worthington, who recently retired after spending about forty years working on the North Atlantic, provides an overview of its water-mass properties and other hydrographic data in *On the North Atlantic Circulation* (Baltimore: The Johns Hopkins University Press, Oceanographic Studies No. 6, 1976). *Edies in Marine Science,* edited by Allan Robinson (New York: Springer-Verla 1983), summarizes current knowledge eddies, and includes some articles on t Gulf Stream, such as Philip L. Richar son's "Gulf Stream Rings" and D. Watts's "Gulf Stream Variability." Ric ardson's "Eddy Kinetic Energy in t North Atlantic from Surface Drifter (*Journal of Geophysical Research,* v 88, pp. 4355–67, published by the Ame can Geophysical Union, 2000 Florida A enue NW, Washington, D.C. 20009) giv measurements of drifting surface buoys the Gulf Stream. Finally, Capt. W Lewis Parker explores the history wooden schooners in "The Operation a Management of the Great New Engla Schooners 1870–1900" (*Maritime Mon graphs and Reports*, No. 5, published the National Maritime Museum, Gree wich, London SE10 9NF).

Bats (p. 52)

Ten bat experts contributed to *Ecolo of Bats* (New York: Plenum Press, 198 an authoritative account edited Thomas H. Kunz. Chapters cover the i portance of roosts; bat reproductio growth and survival; evolutionary alter tives in the physiological ecology of ba ecological aspects of bat activity rhythm morphology; echolocation, insect hearin and feeding ecology of insectivorous ba foraging strategies of plant-visiting ba coevolution between bats and plants; a ecology of insects ectoparasitic on ba *Biology of Bats,* edited by William Wimsatt (New York: Academic Pre 1977), is a multivolumed, comprehensi summary of our knowledge of Chiropte the second largest order of mammals number of species and possibly the mo abundant. It assembles most of the bas anatomical, physiological, behavioral, a ecological information on this group. Pa ticularly relevant to this issue's article bats is J.W. Bradbury's "Social Organiz tion and Communication," in volume 3 the series. See also Daniel H. Janze "Dispersal of Seeds by Vertebrate Gut in *Coevolution,* edited by D.J. Futuyn and Montgomery Slatkin (Sunderlan MA: Sinauer Associates, Inc., 1983, p

62). *The Web of Adaptations*, by
sh ornithologist David W. Snow
v York: Quadrangle/The New York
s Book Co., 1976), an account of the
vior of a number of birds of the
rican tropical forest, devotes some
ters to an exploration of the ways a
es is fitted to life in its environment.

afalaya Delta (p. 60)
odney D. Adams and Robert H.
nann's "Emergence of the Atchafa-
Bay Delta," published in 1980, is the
nontechnical report specifically deal-
vith the Atchafalaya. It is available
3 from its publisher: Louisiana Sea
t, Center for Wetland Resources,
siana State University, Baton Rouge,
siana 70803. Cite publication num-
LSU-T-80-02 when ordering a copy.
e Lockwood's *Atchafalaya: Ameri-
Largest River Basin Swamp* (Baton
ge: Beauregard Press, 1981), a coffee-
-type book with lots of pictures of
siana's delta country, concentrates on
Atchafalaya's inland floodplain.
nd of the River," by Douglas Lee (*Na-
l Geographic*, August 1983), is about
Mississippi River Delta area and the
le who live there. It talks about the
rioration of the Mississippi River
a and recounts the history of the pre-
s deltas. *Geographical Magazine*, a
lar British publication, ran Eugene
er and Edward Maltby's "Louisiana
e Wetland State" (February 1983),
h explains the importance of wet-
s for wildlife and fisheries resources
the problems that have been created
uman impact on the habitat. *Rivers of
World*, by Eberhard Czaya (New
: Van Nostrand Reinhold, 1981), is a
ly written, scientifically accurate
book that elucidates delta formation,
dplain basins, river morphology, and
r such data. Finally, the most enjoy-
and probably the most famous book
t the Mississippi is Mark Twain's
on the Mississippi (New York: Pen-
Books, 1984). Particularly interest-
n light of this issue's article is Twain's
ription of his boat trip down the
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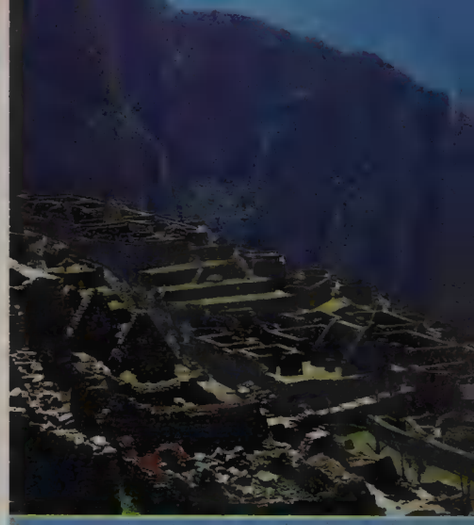

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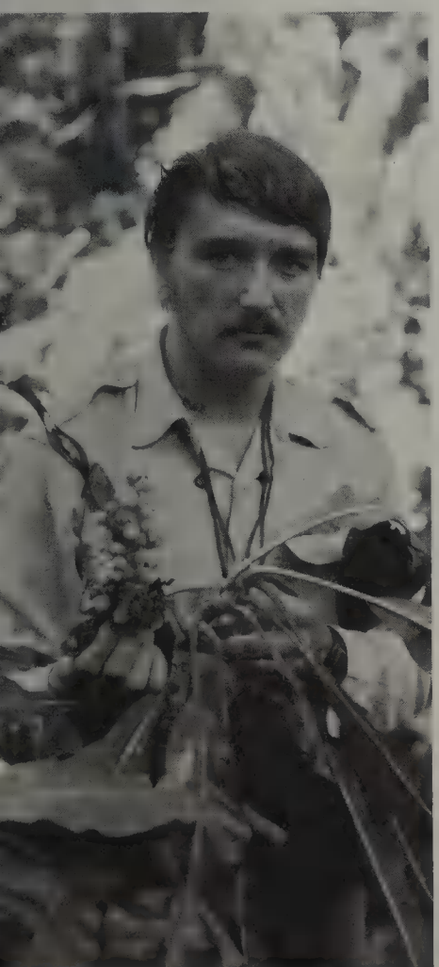
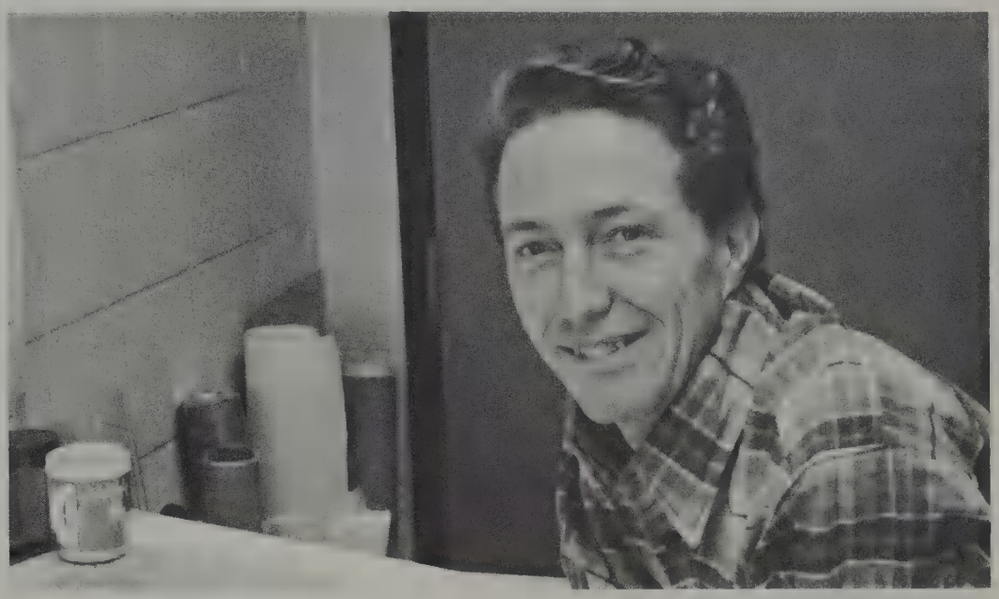
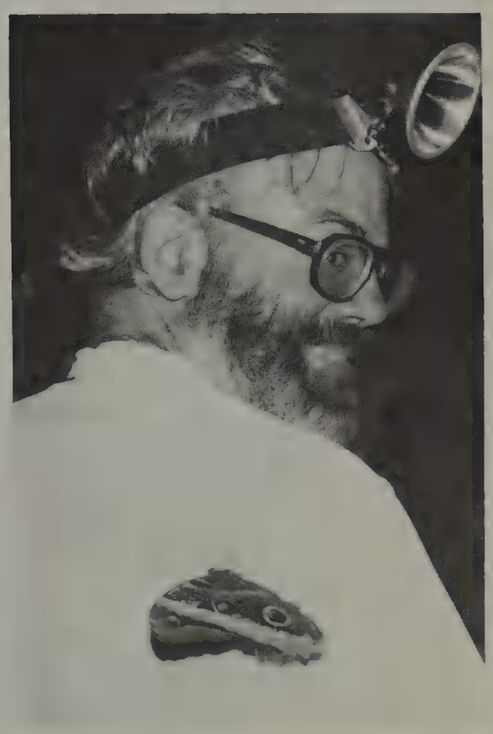
orn into a Mormon family in Utah, **l Alan Cox** (page 36) interrupted his ergraduate work at Brigham Young versity to go on the traditional two- Mormon mission. His mission took to Samoa where he learned some nesian dialects and found, as Dar- had in the Galápagos, "that the hanisms of nature seem exposed." graduate student in biology, Cox re- ed to Samoa to do work on tropical ogy. Since getting his Ph.D. at Har- l in botany, he has gone back to Sa- and to other locations in the South ific many times to study the local . "They are not very well known," ays. "Not many botanists work in the th Pacific. I have the advantage of aking the languages. And the climate onderful." Cox's article in this issue e second he has written for *Natural tory* (see "Sex and the Single wer," November 1983).





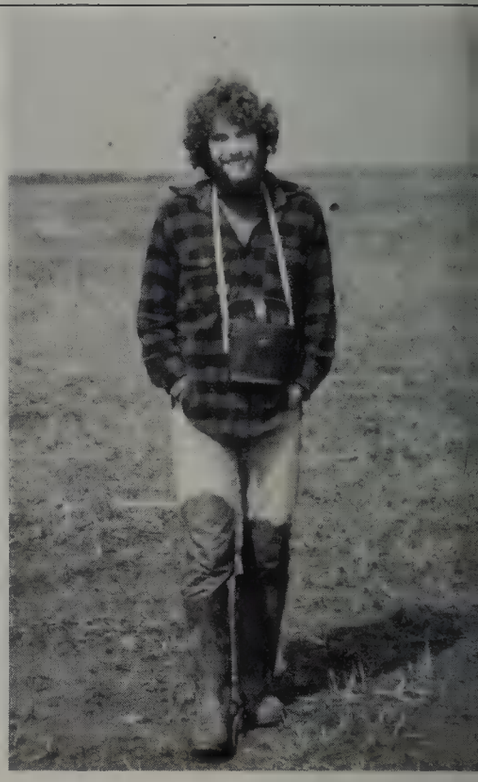
"I usually go on one cruise a year to do hydrographic sampling," says physical oceanographer **Philip L. Richardson** (page 42). "On the cruises we launch surface buoys, deep drifters, and current meter moorings." Richardson has been studying the general circulation of the Atlantic for more than a decade. The cruises have taken him along the Gulf Stream, the eastern Atlantic, and to the equatorial Atlantic. Currently an associate scientist at Woods Hole Oceanographic Institution, he earned a Ph.D. in physical oceanography from the University of Rhode Island in 1974. Richardson is also interested in the historical aspects of oceanography, and he likes to poke around in various libraries and archives to find old maps. In the course of these excursions, Richardson discovered Benjamin Franklin's original chart of the Gulf Stream.

Theodore H. Fleming (page 52) became interested in fruit-eating bats while working in Panama on the Smithsonian Institution's Mammals of Panama Project in the late sixties. His early work dealt with reproductive cycles and food habits, but over the years he has become increasingly curious about how individual bats sustain themselves. Fleming is currently writing a book that summarizes his past ten years of research at Santa Rosa National Park in Costa Rica. It focuses on the behavioral ecology of the short-tailed fruit bat in tropical dry forest and the bat's impact on ecological succession. The forty-three-year-old biology professor is temporarily working at Duke University while on leave from the University of Miami. He spends his spare hours tending to his garden and helping his wife raise two children.



To get to the place where she does her research, **Linda A. Deegan** (page 60) has to drive three hours from Baton Rouge to Morgan City, Louisiana, then rent a motorboat and pilot it another hour to the mouth of the Atchafalaya River.

Since her study site—which will be the home of the Mississippi River's next delta—is so remote, she usually camps out there for a few days at a time. Undue hardships? Deegan doesn't look at it that way. "You just have to be self-sufficient," she says. "If you go down there and forget something, you're sunk." Most researchers in Louisiana State University's coastal ecology unit have made the same adjustment. For thirty-five years, dozens of them have shuttled back and forth to the delta, in a series of projects designed to cover all aspects of the new ecosystem. Some are geomorphologists—"they're the ones who get to name the new delta islands after themselves," Deegan says—others work on vegetation or fish. Deegan, who has studied habitat use by the fish populations in the delta, will start this fall as an assistant professor at the University of Massachusetts, Amherst. Coauthor **Christopher Neill** is a research associate with the coastal ecology program. Neill specializes in coastal marshes, but his emphasis is on management. "We are trying to reduce the environmental impact on the marshes caused by the oil and gas indus-



tries," he says. "Basically, we're looking for ways to restore what's been lost as a result of dredging for canals." Louisiana has the highest rate of land loss in the nation, and one reason, Neill points out, is the lack of concern shown for wetlands.

Working with another professional photographer—in this case a wife—"you get a lot more done," says **Erwin Bauer** (page 94). He and **Peggy Bauer** do stay rather busy. This year, for example, the Bauers have two books coming out—*Photographing Wild Texas* (University of Texas Press) and *Erwin Bauer's Bears in Their World* (Outdoor Life Books). Now, they are on to a work about Africa. The two of them worry less and less about magazine assignments, Erwin says, "because more and more editors are taking pictures from stock houses." So, if they see something that looks promising, like the harbor seals they saw last year on the California coast, they just shoot it and assume it will pay off later. The Bauers were working with 300- and 400-millimeter lenses when they photographed the harbor seal in this month's "The Natural Moment."

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ATURAL HISTORY *(ISSN 0028-0712) is*
blished monthly by the American
useum of Natural History, Central Park
est at 79th Street, New York, N.Y. 10024.
ubscriptions: $20.00 a year. In Canada and all
her countries: $26.00 a year. Second-class
stage paid at New York, N.Y. and at
dditional mailing offices. In Canada second-class
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Anatomy of a Sting

A federal undercover operation may have shut down the black market in falcons, but not without ruffling some feathers

by Jim Robbins

On December 17, 1982, light snow lay on the ground at the Great Falls, Montana, airport. Though the air was cold, the sun, low in the winter sky, shone brightly. Sometime that day, two young brothers from West Germany carried several large boxes across the tarmac and loaded them onto a chartered Falcon jet. They climbed aboard and in a few minutes were airborne. Their destination was Washington, D.C., and their illicit cargo was alive—three gyrfalcons, prized by falconers throughout the world for their speed and superb hunting ability, and three prairie falcons, also used in falconry. All had been captured on the Montana prairie.

Later, after landing at Dulles International Airport, Marcus Ciesielski, then nineteen, and Lothar Ciesielski, then twenty-two, turned over the boxes to a man named François Messouadene. He in turn loaded them into the trunk of a black limousine; then Messouadene and the birds were driven 240 miles to Kennedy International Airport in New York. There, law-enforcement officials say, Messouadene purchased seven first-class tickets on Saudi Arabian Airlines—presumably one for each bird and one for himself—for a flight to Riyadh, the Saudi capital.

All three men are described by federal wildlife agents as members of a worldwide smuggling ring that deals in birds of prey. The limousine driver later told investigators that Messouadene had boasted the birds were going to members of the Saudi Arabian royal family. The Saudis were reportedly paying up to $100,000 a piece for healthy year-old gyrfalcons.

The taking of those six falcons from the wild, their sale to the Ciesielskis, and the events of December 17 were all carefully engineered and monitored by the U.S. Fish and Wildlife Service, as part of a three-year undercover investigation known as Operation Falcon. In this investigation, government agents temporarily entered the black market in raptors, staying in it long enough to find out the identities of the major nest robbers and their customers, and the scope of the activity.

By June 1984, officials apparently felt they had learned enough: 150 law-enforcement officers arrested 39 people and searched dozens more as the first phase of Operation Falcon ended. Marcus Ciesielski was arrested and pleaded guilty; his older brother and Messouadene escaped.

The Arabian connection is only one part of an international black market in birds of prey. This market, the Fish and Wildlife Service and some defendants say, reaches into exotic corners of the world and involves enormous sums of money. Most birds were being bought and sold for use by falconers, although some were traded for breeding purposes.

Some of the other major players who surfaced during Operation Falcon were connected with a Canadian company called Birds of Prey International, which claimed to have sold $750,000 worth of raptors over a two-year period—to the Saudis, among others.

More than thirty Americans in fourteen states were also arrested. Primarily individual falconers—most without previous arrests—they either bought federally protected birds of prey from an undercover informant or manipulated leg bands to make it appear as if birds they had taken illegally from the wild were actually bred in captivity. Agents also claim that some falconers were establishing bogus captive-breeding projects so they could sell some of these "laundered" birds. While it is legal to trap some birds of prey for personal use, it is against federal law to buy or sell birds caught in the wild or to transport them across state lines. Birds bred in captivity can be legally traded.

At the center of Operation Falcon is federal informant John Jeffrey McPartlin, a controversial figure who for three years played the role of an underground dealer in birds of prey. Working with federal agents, McPartlin enticed falconers and traders to buy highly prized raptors that would have been difficult, if not impossible, to come by legally. Many he had trapped or purchased himself. During the course of the investigation McPartlin made more than 1,000 tapes and kept a daily log of his contacts with suspects, which now form the linchpin of the government's case.

But the government's techniques, especially the trapping of wild birds, have drawn the embittered fire of members of the North American Falconers Association (NAFA), some twenty of whom were arrested during Operation Falcon. Spokesmen for the organization claim the government did more harm than good, creating a much more widespread black market than existed before the operation and hurting falcon populations more seriously than individuals have ever done. And, as in the celebrated case of John DeLorean, they and others have criticized the use of the sting as a law-enforcement tactic. "They're like the devil," said Williston Shor, a publicist for the 1,400-member falconers association. "They entice you to do something and then they punish you for it. I'm ashamed to say it was my government."

There are other critics of the investigation, including officials of the Peregrine Fund, an eminent raptor-breeding facility based at Cornell University. But during

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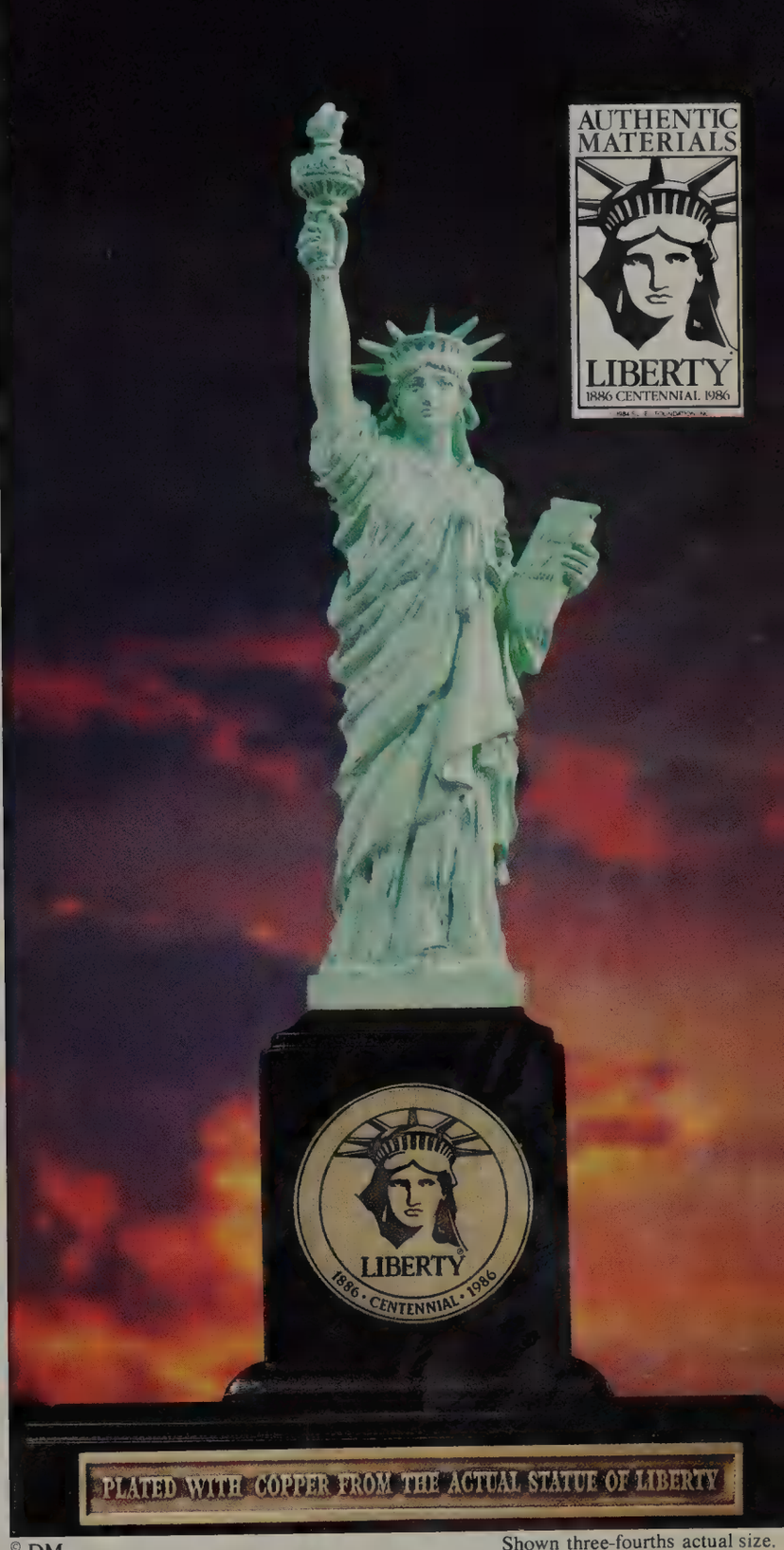

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taped conversations some defendants repeatedly named the Fund as a supplier of illegal birds. Fund officials have adamantly denied the allegations.

Operation Falcon has also received high praise—from wildlife groups that believe widespread aerie robbing was having a severe effect on rare and endangered raptor populations."Operation Falcon uncovered a substantial black market in birds of prey," said Jim Leape, an attorney for the National Audubon Society. "It revealed the need for much stricter regulation of people who take these birds for private use."

Whether Operation Falcon ultimately benefited the species of birds involved is as crucial a question as it is difficult to answer. The total number of birds caught and traded as part of the operation has not been made public, and estimates are still partly guesswork. Officials knew, either directly or indirectly, of 400 to 500 birds traded illegally during Operation Falcon, but they believe that could have represented as little as 10 percent of the actual trade.

Traditionally, falconry uses painstakingly trained birds of prey, which are carried on a gloved hand. Leather straps called jesses are attached to the bird's legs, and a hood is placed over its head. When prey is spotted, either on the ground or in the air, the legs are untethered, the hood removed, and the bird sent heavenward. Historically, raptors have often symbolized a higher spiritual level. Today birds of prey more often seem to stand for elegance and unbridled freedom.

In the Middle East, a cult of prestige currently surrounds certain kinds of birds, particularly long-winged gyrfalcons, because they are big (weighing up to four and a half pounds), fast flyers (possibly up to 200 miles per hour when diving for prey), and as arctic birds, very exotic.

One hundred to 150 nesting pairs of peregrines remain in the continental United States, while there are much larger numbers in Canada. Rough guesses peg the population of arctic gyrfalcons at 4,000 to 5,000 birds, spread throughout Alaska, Canada, and Greenland.

Operation Falcon is officially only three years old, but the idea of a wildlife sting dates back to the mid-1970s, when the Fish and Wildlife Service began trying a new strategy for conserving rare animals. Officials realized then that they were up against a more sophisticated breed of American poacher, who looked upon poaching as a business. The problem was no longer a few people killing deer in the off-season. Trophy bighorn sheep, for example, often taken out of season or from a

George Schaller; Bruce Coleman, Inc.

The $30,000 bird: Young gyrfalcons are prized by Saudi falconers.

national park, are worth up to $20,000, while elk antlers can sell for up to $100 a pound in the Oriental aphrodisiac market. The people dealing in these markets were more efficient than previous generations of poachers, and they operated in organized gangs. The man in a green uniform with a badge, who patrolled forests and fields, could not begin to cope with these rings. In response, the Fish and Wildlife Service formed a Special Operations branch to do undercover work.

When it was begun in 1981, Operation Falcon was one of the largest and most complex cases ever taken on by the new wildlife unit. Donald Schmidt, a former wildlife inspector, was appointed case agent. He conducted the investigation and, helped by others, oversaw Jeffrey McPartlin's education in sting techniques.

McPartlin was no stranger to falconry, or even to illicit dealings in rare birds, having been convicted in 1972 of conspiring to smuggle two gray gyrfalcons out of the country. Several years after the federal misdemeanor conviction, McPartlin, motivated by what he says was a concern about the increased trafficking in raptors, became an unpaid informant for the government. Heavyset, with thinning brown hair and a deep, authoritative voice, the 39-year-old falconer turned informant was a consummate actor during Operation Falcon. His reputation for being able to supply good birds spread throughout the small world of falconry. For three years he convinced dozens of people that he was an outlaw.

After months of selling on a small scale to falconers in the west, McPartlin received a letter from a young man named Lothar Ciesielski, of Cologne, West Germany. "I heard from my falconer friends in Nevada and California that you hav experience with falcons," Ciesielski wrot in his letter. "Maybe I will come to Cal fornia in the next months to visit m friends; by this opportunity I would like t visit you in Montana and exchange som experiences with falcons. I also have som interesting ideas and suggestions I woul like to talk about."

McPartlin responded with a friendl letter and an invitation for Lothar to visi Although agents knew little about th West German, he was their first interna tional contact. The Fish and Wildlife Se vice did not know then what it claims t know now: that the Ciesielski family—fa ther Konrad, mother Dorothea, and th two boys, Marcus and Lothar—ran one o the largest raptor smuggling operations i the world.

Konrad Ciesielski is a short, slightl overweight man in his fifties, who ostensi bly owns an insulating business. Lotha told agents his father has several busi nesses that he uses to hide income fron falcon smuggling. Officials claim the fam ily controls a network of falcon smuggler who take the birds from nests all over th world, including Iceland, the British Isles Canada, Scandinavia, and the Unite States. The Ciesielskis then peddle then to wealthy falconers in the Middle East.

McPartlin also noted in his diary tha Lothar complained that gyrfalcons hac become "too valuable."

"He said that people will now conside murdering each other if they should sho up simultaneously at a gyrfalcon aerie," McPartlin wrote in an entry dated Janu ary 25, 1984.

Lothar arrived in Great Falls on Octo ber 5, 1982. McPartlin, along with a spe cial agent, met the young German and in

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vited him to his home. All conversations, which centered on the type and number of birds McPartlin could provide, were recorded with a body recorder. In his diary McPartlin said Lothar preferred passage females. Passage birds are those on their first migration south; they can fly and hunt but are easier to train than older birds. Lothar offered McPartlin $4,000 a bird "and says I cannot trap too many to meet his needs," McPartlin wrote.

There is a good deal of speculation, given Lothar's age and involvement in a global, jet-setting smuggling ring involving perhaps millions of dollars, that he may have been "puffing," or truth stretching, during the clandestine taping sessions—it's difficult to know for sure. Lothar even claimed that, through a relative of a former Mexican president, he had a permit to take forty falcons out of Mexico. And he claimed to have trapped peregrine falcons in Texas, smuggled them to Mexico, and shipped them from there, under the same permit.

Before the law-enforcement net would be cast in June, Marcus and Lothar Ciesielski would make roughly half a dozen trips to Great Falls to purchase thirty-six gyrfalcons that McPartlin had trapped. They also bought prairie falcons and peregrine falcons. The price of the venerated gyrs would eventually rise to $7,000 each, and the Ciesielskis would do more than $100,000 in business with the informant. These birds were shipped primarily to customers in the Middle East, as well as to falconers in Europe.

During their repeated visits to Montana, the young German brothers would reveal a host of details about their smuggling operation. For example, Lothar said that his mother had once smuggled raptor eggs out of the United States by painting them to look like Easter eggs. Lothar also recounted how his girlfriend had carried eggs through U.S. Customs in a vinyl cosmetics case.

Although McPartlin himself trapped most of the birds sold to the Ciesielskis, he also bought several gyrs from Birds of Prey International (BPI), which specialized in smuggling birds stolen from nests in Northwest Canada. Most of the birds sold by this company went to an overseas market, allegedly including, once again, the royal family of Saudi Arabia.

Glen Luckman, a dapper young Canadian with an Errol Flynn mustache, was McPartlin's initial contact with BPI. In May of 1983 Luckman visited McPartlin in Great Falls. After viewing three gyrfalcons McPartlin had for sale, Luckman told him he could sell the birds in Arabia for $25,000 to $30,000 each, while a white female gyrfalcon could fetch $100,000. He said his going purchase price was $5,000 to $8,000 apiece.

Luckman told McPartlin he needed to take the birds to his partner, John Slaytor, in Ontario. After inspecting the birds, Slaytor offered McPartlin $10,000 plus a peregrine falcon for the three gyrs.

In October of 1983 Luckman told McPartlin that he and his confederates had amassed an impressive stock of raptors: they had removed twenty-four nestling gyrfalcons and fifteen baby peregrines from their nests. They also had twelve eyass, or baby Finnish goshawks, that Luckman had smuggled into Canada from Finland.

McPartlin told Luckman he could sell the gyrfalcons for $7,000 apiece; Luckman brought eight of the birds to Great Falls, and told McPartlin that he had smuggled the birds into the United States by driving his car under a fence at a remote border crossing. On a subsequent trip, he would crash his auto through a barbed wire fence that marked the international boundary.

But Luckman's good fortune eventually ran out. He was arrested by Canadian authorities in June, and pleaded guilty to two felony counts and two misdemeanor counts in U.S. District Court in Great Falls on November 15, 1984. He was fined $23,000. The plea was accepted by the government in exchange for information provided against his partner, John Slaytor. Hundreds of pages of information provided by Luckman led to the arrests of nineteen more people in Canada in late February.

What about the Saudis? What has their reaction been to two independent claims that they have illegally purchased a large number of rare and endangered falcons and used their diplomatic privileges to spirit the birds to the Middle East? Through a Washington attorney, they have quietly denied the accusations, saying the whole plot sounds like "bird feathers." They have not responded to specific charges and did not return phone calls.

Aside from the international conspirators, most of those caught in the domestic end of Operation Falcon to date are relatively small operators. They are primarily devout falconers who fly the birds for sport and who were apparently unable to resist the lure of falconry's most dramatic birds—peregrine falcons and gyrfalcons, two species almost impossible to obtain legally. Many of those arrested said McPartlin repeatedly called them with offers for birds, often repeatedly lowering the price if they refused. As one Texas attorney said, "It's like having someone bring Marilyn Monroe by and asking if she can spend the night."

Most of these small-timers were charged with felonies and allowed to plead guilty to misdemeanors—such crimes as transporting protected birds across state lines, possession of an endangered species, and manipulating federal raptor bands.

The laundering of birds, or "covering" them with paperwork to make them appear to be domestically bred, is difficult but not as complicated as actually breeding the birds. Raptors require very carefully controlled environments for mating and incubation, and the proper equipment is costly. Extra bands are easier to come by: bands from birds that die can be reused or breeders can claim to have raised more birds than they actually did and request additional bands.

By February all of the court cases stemming from Operation Falcon had been concluded, and all except two of the defendants pleaded or were found guilty.

But officials don't expect the criminal charges to end there. It is standard law-enforcement procedure to arrest the little guys, usually the least efficient lawbreakers and the easiest to apprehend, and then, by offering leniency in exchange for cooperation, gather evidence against the career criminal. As a result of these "rollovers" officials expect a second, and perhaps third, wave of arrests of thirty to forty suspects.

Meanwhile, however, the Fish and Wildlife Service has made other kinds of waves by directing its investigators toward the prestigious Peregrine Fund, which raises and releases captive peregrine falcons into the wild in hopes they will reestablish a natural population. The Fund, the world's largest breeder of raptors, has three breeding facilities—one at Cornell University in Ithaca, New York, one in Boise, Idaho, at the recently established World Center for Birds of Prey, and a third in Santa Cruz, California. Breeders at these three locations have already raised several hundred birds and released them into the wild. As a result, peregrine falcons are nesting again in New York City, Baltimore, and other parts of the east, as well as in places in the west from which they had disappeared.

Investigative reports on Lothar Ciesielski indicate that he repeatedly accused the Peregrine Fund of selling birds illegally, a charge investigators took seriously. In a letter to Thomas Cade, director of the Peregrine Fund, Harrison B. Tordoff, former president of the American Ornithologist's Union, described the inspection of a raptor-breeding facility owned by a friend. In addition to the in-

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6983. Bach: Organ [illegible]erpieces—*Toccata & gue in D Minor,* etc. Newman (Sine Qua Non)

7061. Bach: Goldberg [illegible]riations—Glenn Gould *igital*—CBS Masterworks)

0647. Bach: Unaccom-[illegible]anied Cello Suites 1, 2 performed by Yo-Yo Ma *igital*—CBS Masterworks)

9714. Bartok: Concerto [illegible] Orchestra; Dance Suite Solti conducts Chicago m. *(Digital*—London)

6090. Beethoven: Cello [illegible]onatas 4 & 5—Yo-Yo Ma, ello; Emanuel Ax, piano *igital*—CBS Masterworks)

3765. Beethoven: Piano [illegible]onatas 7 & 23 (Appas-onata)—Murray Perahia *igital*—CBS Masterworks)

1570. Beethoven: Sym-[illegible]hony No. 5; Schubert: ymph. No. 8 (Unfinished) Maazel, Vienna Philhar. *igital*—CBS Masterworks)

2874. Beethoven: ymphony No. 9 (Choral) Ormandy and the Phila-elphia Orch. (Columbia)

7221. Beethoven: [illegible]olin Concerto—Menuhin; asur, Leipzig Gewand-aus *(Digital*—Angel)

1595. Bizet: Carmen [illegible]uite: L'Arlésienne [illegible]uites 1, 2—Ozawa, Orch. ational *(Digital*—Angel)

3293. Bolling: Suite For [illegible]ute and Jazz Piano—ampal, Bolling (Columbia)

2668. Brahms: Sym-[illegible]hony No. 1—Tennstedt ond. London Philharmonic rch. *(Digital*—Angel)

334243. Brahms: Piano Concerto No. 1—Weissen-berg; Muti, Philadelphia Orch. *(Digital*—Angel)

330118. Brahms: String [illegible]Quintets in F and G Major—Boston Sym. Chamber Players *(Digital*—Nonesuch)

333518. Bruckner: Sym-phony No. 7—Chailly, RSO Berlin *(Digital*—London)

246843. Chopin: Mazurkas, Etudes, etc.—Vladimir Horowitz, piano (Columbia)

330100. Chopin: Piano Concerto No. 2; Saint-Saens: Concerto No. 2—Licad; Previn, London Phil. *(Digital*—CBS Masterworks)

328439. Copland: Rodeo; Dance Symphony; El Salon Mexico; Fanfare for Com-mon Man—Dorati, Detroit Sym. *(Digital*—London)

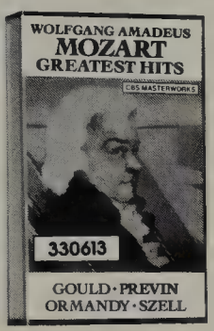
322816. Debussy: La Mer; Nocturnes—Michael Tilson Thomas, Philharmonia Orch. *(Digital*—CBS Masterworks)

304931. Debussy: Image[illegible] For Orchestra; Prelude To An Afternoon Of A Faun—Previn, London Sym. *(Digital*—Angel)

325183. Dvorak: Sym-phony No. 9 (New World) —Solti, Chicago Symph. Orch. *(Digital*—London)

321471. Gershwin: Piano Concerto in F; American in Paris; Rhapsody in Blue —Andre Previn and the London Symphony (Angel)

331314. Gershwin: An American In Paris—plus Grainger's *Fantasy on Porgy & Bess*—pianists Katia & Marielle Labeque *(Digital*—Angel)



326488. Gershwin: Porgy [illegible]& Bess Suite; Second Rhapsody; Cuban Over-ture—Previn, London Symph. *(Digital*—Angel)

319004. Glass, Philip: The Photographer (CBS)

329615. Handel: Water Music: Malgorie, La Grande Ecurie & la Chambre duRoy *(Digital*—CBS Masterworks)

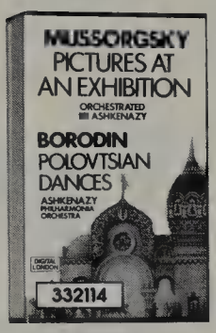
323543. Handel: Royal Fireworks Music; Oboe Concertos 1-3—Karl Mun-chinger, Stuttgart Chamber Orch. *(Digital*—London)

332569. Haydn: Symphony No. 94 (Surprise)**, No. 100** (Military)—Solti, London Phil. *(Digital*—London)

326272. Holst: The Planets —Bernstein, New York Phil. (CBS Great Performances)

321208. Liszt: Hungarian Rhapsodies 2,3,5; Meph-isto Waltz—Willi Boskovksy, London Phil. (Angel)

334508. Mahler: [illegible]Symphony No. 1 (Titan)— Muti cond. Philadelphia Orch. *(Digital*—Angel)



329094-399097. Mahler: Symphony No. 2 (Resur-rection)—Lorin Maazel, Vienna Phil. (Counts as 2– *Digital*—CBS Masterworks)

318824. Mendelssohn: Symphony No. 4 (Italian); **Schumann: Symphony No. 4**—Tennstedt, Berlin Phil. *(Digital*—Angel)

330142. Mendelssohn: Violin Concerto; Saint-Saens: Concerto No. 3— Cho-Liang Lin; Thomas con. (Digital—CBS Masterworks)

325365. Mozart: Eine Kleine Nachtmusik; Symph. No. 40—Casals, Marlboro Festival Orch. (CBS Portrait)

332551. Mozart: Exultate, jubilate; Regina coeli; etc. —Emma Kirby, soprano; Christopher Hogwood, con. *(Digital*—L'Oiseau-lyre)

321224. Mozart: Overtures —Don Giovanni; Cosi fan tutte; Marriage of Figaro; etc. Marriner, Academy of St. Martin *(Digital*—Angel)

329870. Mozart: Piano Concertos No. 19 [illegible]& 23— Perahia; English Chamber *(Digital*—CBS Masterworks)

316406. Pachelbel Canon [illegible]& Other Baroque Favorites Boyd Neel, Toronto Cham-ber Orch. *(Digital*—MMG)

318691. Prokofiev: Love For Three Oranges Suite; [illegible]Lt. Kije Suite—Michael Tilson Thomas, Los Angeles Phil. (CBS Masterworks)

245043. Rachmaninoff: Piano Concertos Nos. 1 & 2 —Ashkenazy; Previn, London Sym. (London)

334565. Rachmaninoff: Symphony No. 2 (complete version)—Rattle and L.A. Phil. *(Digital*—Angel)

318451. Ravel: Bolero; Pavane; Daphnis Et Chloe (Suite No. 2)—Andre Previn, London Symphony (Angel)

324533. Respighi: Feste Romane; Pines [illegible]& Fountains Of Rome—Dutoit, Orch. de Montreal *(Digital*—London)

318436. Rimsky-Korsakov: Scheherazade—Svetlanov, London Symphony (Angel)

325100. Saint-Saens: Carnival of the Animals —also works by Debussy, Satie. Philip Jones Brass Ensemble *(Digital*—London)

310870-390872. Johann Strauss' Greatest Waltzes Ormandy, Szell, Bernstein (Counts as 2—Columbia)

202796. Richard Strauss: Also Sprach Zarathustra —Bernstein, New York Philharmonic (Columbia)

326405. Stravinsky: The Firebird (complete ballet) —Dohnanyi, Vienna Philhar-monic *(Digital*—London)

281493. Stravinsky: Rite Of Spring. Zubin Mehta, N.Y. Phil. (Columbia)

318444. Tchaikovsky: 1812 Overture; Serenade For Strings—Muti, Phila. Orch. *(Digital*—Angel)

329169. Tchaikovsky: Symphony No. 4—Lorin Maazel, Cleveland Orch. (CBS Masterworks)

332544. Vivaldi: 6 Flute Concerti (Op. 10)—Rampal; Scimone, I Solisti Veneti *(Digital*—CBS Masterworks)

324525. An Isaac Stern Vivaldi Gala: Concertos For 2 and 3 Violins; etc. Stern, Zukerman, Perlman, others (CBS Masterworks)

323147. Wagner: Orchestral Music from "The Ring"— Sir Georg Solti, Chicago Sym. *(Digital*—London)

310086. Wagner: Overtures —*Flying Dutchman; Rienzi;* etc. Maazel, Philharmonia Orch. (Columbia)

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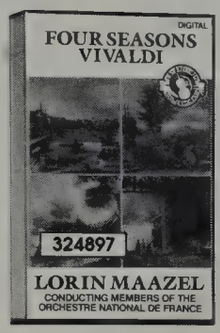
331942. The Academy—By Request. Marriner and Academy of St. Martin-In-The-Fields. Schubert, Bach, etc. *(Digital*—Angel)



320013. Nancy Allen—virtuoso harpist in music by Ravel and Debussy. With Rampal, Tokyo String Quartet *(Digital*—Angel)

292003-392001. Curtain Raisers—World's Favorite Overtures. *Die Fledermaus; Carmen, William Tell;* etc. (Counts as 2—Columbia)

326553. Placido Domingo —Great Love Scenes. With Te Kanawa, Cotrubas and Scotto (CBS Masterworks)

334714-394718. Glenn Gould—Bach, Vol. 2. *French Suites (Nos. 1-6); Overture In The French Style* (Counts as 2— CBS Masterworks)

326595. Igor Kipnis—Music For The Kings Of France. Harpsichord suites by Marchand and Couperin (Nonesuch Silver Series)

321851. Wynton Marsalis Plays Trumpet Concertos. Haydn, Hummel, L. Mozart *(Digital*—CBS Masterworks)

326611. Christopher Parkening—Sacred Music For The Guitar. Mozart, Bach, etc. *(Digital*—Angel)

327551. Luciano Pavarotti —Mamma. Popular Italian songs arranged by Henry Mancini *(Digital*—London)

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319582. Jean-Pierre Rampal Plays Scott Joplin. *The Entertainer, Maple Leaf Rag,* many more (CBS)

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330399. Kiri Te Kanawa—Come To The Fair. Folk Songs *(Digital*—Angel)

332536. Kiri Te Kanawa—Songs of the Auvergne, Vol. 2. *Also* Villa-Lobos: Bachianas Brasileiras No. 5 *(Digital*—Angel)

333112. Andreas Vollenweider—White Winds. The inventive harpist's latest *(Digital*—CBS)

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spection, Tordoff said, federal wildlife agents interrogated the breeder.

"I can't recall it word for word," Tordoff said of the questioning, "but the gist was that allegations had been made by unnamed persons against the Peregrine Fund, and therefore federal agents had a duty to investigate them." Among the points raised during questioning was the charge that the Fund had taken eggs and young of wild peregrines, had been selling birds to falconers in the Middle East, Europe, and the United States, and had been rewarding large donors to the Fund with falcons for their personal use.

Tom Cade believes the government has unreasonably damaged the Fund's reputation in the small circle of falcon breeders by asking virtually all of those arrested whether they knew about illegal activities by the Fund. "It leads the person who is being interrogated to believe that the Peregrine Fund engaged in illegal activities," Cade said. "They stem from allegations made about us from German traffickers. They're complete fabrications. [The Fish and Wildlife Service] found nothing because there is nothing to find. We've been under investigation for ten years. How long does an investigation have to go on before there's any evidence of wrongdoing?" In at least two cases, Cade said, he was denied funding because the Fund was "under suspicion." The government has refused to comment on this aspect of Operation Falcon because it is "an ongoing investigation."

Williston Shor, publicist for the falconers association, has fired off a litany of accusations against the Special Operations branch, in letters and press releases. Operation Falcon has given NAFA, which had twenty members arrested, a resplendent black eye and confirmed a public perception that falconers have fought for years—that they care little for preservation of the species but are primarily interested in owning birds. NAFA fears the arrests may bring a revocation of the 1983 regulations that allowed them to buy and sell captive raptors.

In fact, shortly after the arrests, the National Audubon Society and the National Wildlife Federation petitioned Secretary of the Interior William Clark to review the regulations, with an eye toward disallowing sales of birds bred in captivity. Both groups opposed the regulations when they were first proposed. However, Shor points out that falconers attempted to turn McPartlin in several times—evidence, he contends, that falconers keep their own ranks groomed. He also claims that McPartlin, by trapping thirty-six gyrfalcons, damaged a wild resource.

But the Audubon Society doesn't agree. According to Audubon Society spokesman Amos Eno, 400 to 500 birds were sold illegally during the three years of Operation Falcon. Only 40 to 50 of these were removed from the wild by McPartlin. "I think the service's use of the birds was conservative," says Eno.

Agents say that during the entire course of the investigation, the total number of peregrine falcons trapped or stolen from nests in the western United States for Operation Falcon was between 10 and 20. With 100 to 150 pairs of peregrines in the west, those numbers alone may not decimate the species. The impact, however, according to William Burnham, vice-president of the Peregrine Fund, manager of the World Center for Birds of Prey in Boise, and a leading expert on western peregrine populations, could be serious.

"It depends on where they were removed from," Burnham said. "We've found quite a few birds in Arizona and Utah that are reproducing fairly well. It's difficult to say if it would have a dramatic impact in these areas. On the other hand if you take the birds from Montana or Colorado it could harm the species. If you're dealing with an endangered species and remove ten to twenty birds it's certainly not going to do the population any good." According to government officials, most peregrines taken from the wild during Operation Falcon came from Arizona and Utah.

Entrapment has been one of the most constant complaints about Operation Falcon. "They entrapped people," said Ralph Rogers of Winifred, Montana, who is a regional director of NAFA. "Instead of packets of dope or bundles of money, they used a precious wild resource."

But Justice Department attorneys argue that sting tactics are a legitimate law-enforcement tool. Christopher Nuechterlein, who has prosecuted several Operation Falcon cases for the government, says a defendant can win on an entrapment plea only if he can prove he was intimidated into doing something he wouldn't otherwise have done. "The government provided an opportunity," he says. "It did not overpower their free will."

In November the entrapment argument was put to the test during the trial of three men from the Dallas area arrested during Operation Falcon: Dr. Greg Moore, a veterinarian, and Dr. James E. Doyle, a plastic surgeon, who were charged with buying and transporting peregrine falcons, an endangered species, and Burt Loessberg, charged with conspiracy to violate federal wildlife laws. Five defense attorneys claimed that the government's undercover informant, McPartlin, had befriended their clients and then led them into wrongdoing. They made a great deal of McPartlin's criminal record. They also accused McPartlin of luring as many people as possible into his web in order to hold on to his job, and its $2,200 a month salary, as long as possible.

The jury's decision was a confusing one. Moore was acquitted, the jury foreman reported, because he was entrapped; Loessberg was acquitted because of a lack of evidence. Doyle, however, was found guilty. "We felt he walked into it with his eyes wide open," said Dan Whitfield, the jury foreman.

The undercover portion of Operation Falcon drew to a conclusion in the early morning hours of June 29, 1984. In motel rooms around the country, more than 150 law-enforcement officers gathered for the bust. At precisely the same time, in groups of six, seven, and eight, they descended on the falconers and breeders, aimed guns at their heads, and handcuffed them.

But there were several large holes in the tightening dragnet. Lothar Ciesielski, who had masterminded most of the smuggling in the United States, was indicted, but he was home in West Germany at the time, facing wildlife charges unrelated to Operation Falcon. Marcus Ciesielski was not so lucky; he had been convinced by McPartlin to travel to Montana to pick up some more gyrfalcons. He arrived in Calgary, Alberta, the night before the warrants were to expire, so the Fish and Wildlife Service sent a chartered plane to Canada to bring the youngest Ciesielski to the United States. After spending two months in jail awaiting trial, Marcus pleaded guilty to three misdemeanors. He was fined $10,000 and allowed to leave the country. In addition to Lothar, officials also missed François Messouadene.

It's extremely difficult to measure the impact of an investigation like Operation Falcon on the bird populations it was intended to protect. The Fish and Wildlife Service may have shut off the black market, both by arresting some of the principals and by demonstrating that wildlife crimes are being taken seriously. But as with drug trading, the operation may simply have forced illegal activity further underground—driving the prices higher and making the rewards of selling a wild falcon, or owning one, seem all the more worth the trouble. Its true effect will only become clearer in the months ahead.

Jim Robbins, a freelance writer based in Helena, Montana, writes about the Rocky Mountain region for the New York Times *and other publications.*

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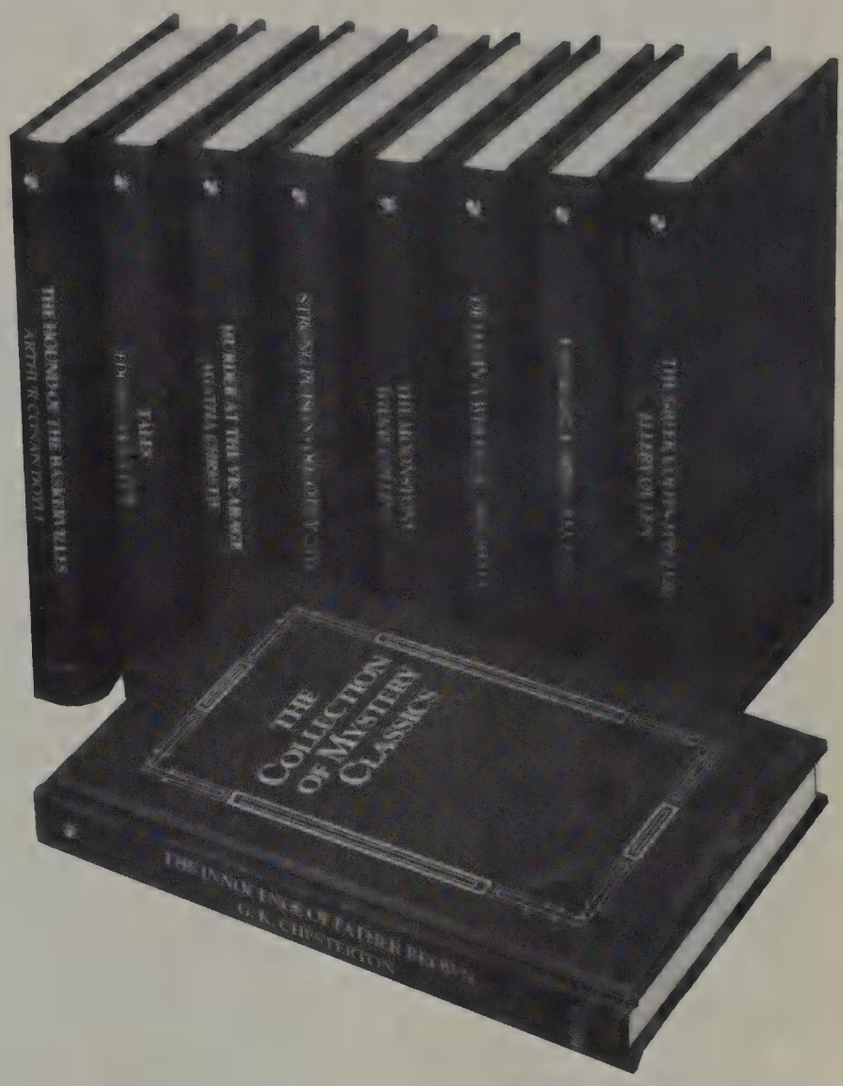

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Here Goes Nothing

"But when nothing becomes something, the inherent power of evolution, normally an exquisitely conservative force, can break forth"

by Stephen Jay Gould

Goliath paid the highest of all prices to learn the most elementary of all lessons—thou shalt not judge intrinsic quality by external appearance. When the giant first saw David, "he disdained him; for he was but a youth, and ruddy, and of a fair contenance" (1 Sam. 17: 42). Saul had been similarly unimpressed when David presented himself as an opponent for Goliath and savior of Israel. Saul doubted out loud: "for thou art but a youth, and he a man of war from his youth" (1 Sam. 17: 33). But David persuaded Saul by telling him that actions speak louder than appearances—for David, as a young shepherd, had rescued a lamb from a predacious lion: "I went out after him, and smote him, and delivered it out of his mouth" (1 Sam. 17: 35).

This old tale presents a double-entendre to introduce this column. It serves first as a preface to my opening story about a famous insight deceptively clothed in drab appearance—and second as a quirky lead to the body of this essay, a tale of animals that really do deliver from their mouths: *Rheobatrachus silus,* an Australian frog that swallows its fertilized eggs, broods tadpoles in its stomach, and gives birth to young frogs through its mouth.

Henry Walter Bates landed at Pará (now Belém), Brazil, near the mouth of the Amazon, in 1848. He arrived with Alfred Russel Wallace, who had suggested the trip to tropical jungles, arguing that a direct study of nature at her richest might elucidate the origin of species and also provide many fine specimens for sale. Wallace returned to England in 1852, but Bates remained for eleven years, collecting nearly 8,000 new species (mostly insects) and exploring the entire Amazon valley.

In 1863, Bates published his two-volume classic, perhaps the greatest work of nineteenth-century natural history and travel, *The Naturalist on the River Amazons.* But two years earlier, Bates had hidden his most exciting discovery in a technical paper with a disarmingly pedestrian title: "Contributions to an Insect Fauna of the Amazon Valley," published in the *Transactions of the Linnaean Society.* The reviewer of Bates's paper (*Natural History Reviews,* 1863, pp. 219–24) lauded Bates's insight but lamented the ill-chosen label: "From its unpretending and somewhat indefinite title," he wrote, "we fear [that Bates's work] may be overlooked in the ever-flowing rush of scientific literature." The reviewer therefore sought to rescue Bates from his own modesty by providing a bit of publicity for the discovery. Fortunately, he had sufficient oomph to give Bates a good send-off. The reviewer was Charles Darwin, and he added a section on Bates's insight to the last edition of the *Origin of Species.*

Bates had discovered and correctly explained the major style of protective mimicry in animals. In Batesian mimicry (as we still call it today), uncommon and tasty animals (the mimics) gain protection by evolving uncanny resemblance to abundant and foul-tasting creatures (the models) that predators learn to avoid. The viceroy butterfly is a dead ringer for the monarch, which, as a caterpillar, consumes enough noxious poisons from its favored plant foods to sicken any untutored bird. (Vomiting birds have become a cliché of natural history films. Once afflicted, twice shy, as the old saying goes. The tale may be more than twice told, but many cognoscenti do not realize that the viceroy's name memorializes its mimicry—for this butterfly is the surrogate, or vice-king, to the ruler, or monarch, itself.)

Darwin delighted in Bates's discovery because he viewed mimicry as such a fine demonstration of evolution in action. Creationism, Darwin consistently argued, cannot be disproved directly because it claims to explain everything. Creationism becomes impervious to test and, therefore, useless to science. Evolutionists must proceed by showing that any creationist explanation becomes a *reductio ad absurdum* by twists of illogic and special pleading required to preserve the idea of God's unalterable will in the face of evidence for historical change.

In his review of Bates's paper, Darwin emphasizes that creationists must explain the precision of duplicity by mimics as a simple act of divine construction—"they were thus clothed from the hour of their creation," he writes. Such a claim, Darwin then argues, is even worse than wrong because it stymies science by providing no possible test for truth or falsity—it is an argument "made at the expense of putting an effectual bar to all further inquiry." Darwin then presents his *reductio ad absurdum,* showing that any fair-minded person must view mimicry as a product of historical change.

Creationists had made a central distinction between true species, or entities created by God, and mere varieties, or products of small changes permitted within a created type (breeds of dogs or strains of wheat, for example). But Bates had shown that some mimics are true species and others only varieties of species that lack mimetic features in regions not inhabited by the model. Would God have created some mimics from the dust of the earth but allowed others to reach their precision by

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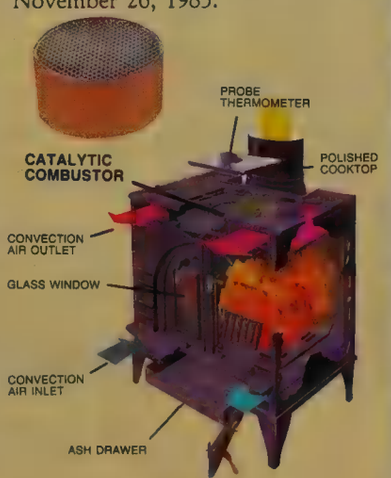

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limited natural selection within the confines of a created type? Is it not more reasonable to propose that mimicking species began as varieties and then evolved further to become separate entities? And much worse for creationists: Bates had shown that some mimicking species resemble models that are only varieties. Would God have created a mimic from scratch to resemble another form that evolved (in strictly limited fashion) to its current state? God may work in strange ways, his wonders to perform—but would he really so tax our credulity? The historical explanation makes so much more sense.

But if mimicry became a source of delight for Darwin, it also presented a serious problem. We may easily grasp the necessity for a historical account. We may understand *how* the system works once all its elements develop, but *why* does this process of mimicry ever begin? What starts it off, and what propels it forward? Why, in Darwin's words, "to the perplexity of naturalists, has nature condescended to the tricks of the stage?" More specifically: any butterfly mimic, in the rich faunas of the Amazon valley, shares its space with many potential models. Why does a mimic converge upon one particular model? We can understand how natural selection might perfect a resemblance already well established, but what begins the process along one of many potential pathways—especially since we can scarcely imagine that a 1 or 2 percent resemblance to a model provides much, if any, advantage for a mimic. This old dilemma in evolutionary theory even has a name in the jargon of my profession—the problem of the "incipient stages of useful structures." Darwin had a good answer for mimicry, and I will return to it after a long story about frogs—the central subject of this essay and another illustration of the same principle that Darwin established to resolve the dilemma of incipient stages.

We remember Darwin's *Beagle* voyage primarily for the big and spectacular animals that he discovered or studied: the fossil *Toxodon* and the giant Galápagos tortoises. But many small creatures, though less celebrated, brought enormous scientific reward—among them a Chilean frog appropriately named *Rhinoderma darwini*. Most frogs lay their eggs in water and then allow the tadpoles to make their own way, but many species have evolved various styles of parental care, and the range of these adaptations extols nature's unity in diversity.

In *R. darwini*, males ingest the fertilized eggs and brood them in the large throat pouches usually reserved for an earlier act of courtship—the incessant croaking that defines territory and attracts females. Up to fifteen young may fill the pouch, puffing out all along the father's ventral (lower) surface and compressing the vital organs above. G.B. Howes ended his classical account of this curious life style (*Proceedings of the Zoological Society of London*, 1888) with a charming anthropomorphism. Previous students of *Rhinoderma*, he noted, had supposed that the male does not feed while carrying his young. But Howes dissected a brooding male and found its stomach full of beetles and flies and its large intestine clogged with "excreta like that of a normal individual." He concluded, with an almost palpable sigh of relief, "that this extraordinary paternal instinct does not lead up to that self-abnegation" postulated by previous authors.

But nature consistently frustrates our attempts to read intrinsic solicitude into her ways. In November 1973, two Australian scientists discovered a form of parental care that must preclude feeding, for these frogs brood their young in their stomachs and then give birth through their mouths. And we can scarcely imagine that a single organ acts as a nurturing uterus and a site of acid digestion at the same time.

Rheobatrachus silus, a small aquatic frog living under stones or in rock pools of shallow streams and rills in a small area of southeast Queensland, was first discovered and described in 1973. Later that year, C.J. Corben and G.J. Ingram of Brisbane attempted to transfer a specimen from one aquarium to another. To their astonishment, it "rose to the surface of the water and, after compression of the lateral body muscles, propulsively ejected from the mouth six living tadpoles" (from the original description published by Corben, Ingram, and M.J. Tyler in *Science*, vol. 186, 1974, p. 946). They initially assumed, from their knowledge of *Rhinoderma*, that their brooder was a male rearing young in its throat pouch. Eighteen days later, they found a young frog swimming beside its parent; two days later, a further pair emerged unobserved in the night. At that point, they decided (as the euphemism goes) to "sacrifice" their golden goose. But the parent, when grasped, "ejected by propulsive vomiting eight juveniles in the space of no more than two seconds. Over the next few minutes a further five juveniles were ejected." They then dissected the parent and received their biggest surprise. The frog had no vocal sac. It was a female with "a very large, thin-walled, dilated stomach"—the obvious home of the next generation.

Natural birth had not yet been observed in *Rheobatrachus*. All young had either emerged unobserved or been vomited forth as a violent reaction after handling. The first young had greeted the outside world prematurely as tadpoles (since development clearly proceeds all the way to froghood in the mother's stomach, as later births demonstrated).

Art then frustrated nature, and a second observation also failed to resolve the mode of natural birth. In January 1978, a pregnant female was shipped express airfreight from Brisbane to Adelaide for observation. But the poor frog was—yes, you guessed it—"delayed" by an industrial dispute. The mother, still hanging on, arrived surrounded by twenty-one dead young; a twenty-second frog remained in her stomach upon dissection. Finally, in 1979, K.R. McDonald and D.B. Carter successfully transported two pregnant females to Adelaide—and the great event was finally recorded. The first female, carefully set up for photography, frustrated all hopes by vomiting six juveniles "at great speed, flying upwards . . . for approximately one meter . . . a substantial distance relative to the body size of the female." But the second mother obliged. Of her twenty-seven offspring, two appeared gently and, apparently, voluntarily. The mother "partially emerged from the water, shook her head, opened her mouth and two babies actively struggled out." The photo of a fully formed baby frog, resting on its parent's tongue before birth, has already become a classic of natural history. This second female, about two inches long, weighed 11.62 grams after birth. Her twenty-six children weighed 7.66 grams, or 66 percent of her weight without them. An admirable effort indeed!

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Rheobatrachus inspired great excitement among Australian scientists, and research groups in Adelaide and Brisbane have been studying this frog intensively, with all work admirably summarized and discussed in a volume edited by M.J. Tyler (*The Gastric Brooding Frog,* Croom Helm, London and Canberra, 1983). Rarely has such extensive and coordinated information been presented on a natural oddity, and we are grateful to these Australian scientists for bringing together their work in such a useful way.

This volume also presents enough detail (usually lacking in technical publications) to give nonscientists a feel for the actual procedures of research, warts and all (an appropriate metaphor for the subject). Glen Ingram's article on natural history, for example, enumerates all the day-to-day dilemmas that technical papers rarely mention: slippery bodies that elude capture; simple difficulties in seeing a small, shy frog that lives in inaccessible places (Ingram learned to identify *Rheobatrachus* by the characteristic ripples made by its jump into water); rain, fog, and dampness; and regeneration that frustrates identification (ecologists must recognize individual animals in order to monitor size and movement of populations by mark-recapture techniques. Amphibians and reptiles are traditionally marked by distinctive patterns of toe clipping, a painless and unobtrusive procedure. But *Rheobatrachus* frustrates tradition by regenerating its clipped toes, and Ingram could not reidentify his original captures). To this, we must add the usually unacknowledged bane of all natural history: boredom. You don't see your animals most of the time; so you wait and wait and wait (not always pleasant on the boggy banks of a stream in rainy season). Somehow, though, such plagues seem appropriate enough, given the subject. Frogs, after all, stand among the ten Mosaic originals: "I will smite all thy borders with frogs: And the river shall bring forth frogs abundantly, which shall go up and come into thine house, and into thy bedchambers, and upon thy bed ... and into thine ovens, and into thy kneading troughs" (Exod. 8: 2–3).

The biblical author of Exodus was, unfortunately, not describing *Rheobatrachus,* a rare animal indeed. Not a single *Rheobatrachus silus* has been seen in its natural habitat since 1979. A series of dry summers and late rains has restricted the range of this aquatic frog—and five years of no sitings must raise fears about its extinction. Fortunately, a second species, named *R. vitellinus,* was discovered in January 1984, living in shallow sections of fast-flowing streams, about five hundred miles north of the range of *R. silus.* This slightly larger version (up to three inches in length) is also a gastric brooder; twenty-two baby frogs inhabited the stomach of a pregnant female.

When discussed as a disembodied oddity (the problem with traditional, narrative writing in natural history), *Rheobatrachus* may pique our interest but not our intellect. Placed into a proper context among other objects of nature's diversity—the "comparative approach" so characteristic of evolutionary biology—gastric brooding in *Rheobatrachus* embodies a message of great theoretical interest. *Rheobatrachus,* in one sense, stands alone. No other vertebrate swallows its own fertilized eggs, converts its stomach into a brood pouch, and gives birth through its mouth. But in another sense, *Rheobatrachus* represents just one solution to a common problem among frogs.

In his review of parental care, R.W. McDiarmid argues that frogs display "the greatest array of reproductive modes found in any vertebrates" (see his article in G.M. Burghardt and M. Bekoff, *The Development of Behavior,* New York, Garland Press, 1978). Much inconclusive speculation has been devoted to reasons for the frequent and independent evolution of brooding (and other forms of parental care) in frogs—a profound departure, after all, from the usual amphibian habit of laying eggs in water and permitting the young to pass their early lives as unattended aquatic tadpoles. Several authors have suggested the following common denominator: in many habitats, and for a variety of reasons, life as a free-swimming tadpole may become sufficiently uninviting to impose strong evolutionary pressure for bypassing this stage and undergoing "direct development" from egg to completed frog. Brooding is an excellent strategy for direct development—since tadpole life may be spent in a brood pouch, and the bad old world need not be faced directly before froghood.

In any case, brooding has evolved often in frogs, and in an astonishing variety of modes. As a minimal encumbrance and modification, some frogs simply attach eggs to their exteriors. Males of Kammerer's downfall, the midwife toad *Alytes obstetricans,* wrap strings of eggs about their legs and carry them in tow.

At the other extreme of modification, some frogs have evolved special brood pouches in unconventional places. The female *Gastrotheca riobambae,* an Ecuadorean frog from Andean valleys, develops a pouch on her back, with an opening near the rear and an internal extension nearly to her head. The male places fertilized eggs in her pouch, where they develop under the skin of her back for five to six weeks before emerging as late-stage tadpoles.

In another Australian frog, *Assa darlingtoni,* males develop pouches on their undersides, opening near their hind legs but extending forward to the front legs (see article by G.J. Ingram, M. Anstis, and C.J. Corben, *Herpetologia,* vol. 31, 1975, pp. 425–29). Females lay their eggs among leaves. When they hatch, the male places himself in the middle of the mass and either coats himself with jelly from the spawn or, perhaps, secretes a slippery substance himself. The emerging tadpoles then perform like no other amphibian: they move in an ungainly fashion by bending their bodies, head toward tail, and then springing sideways and forward. In this inefficient manner, they migrate over the slippery body of their father and enter the brood pouch under their own steam. (I am almost tempted to say, given the Australian venue, that these creatures have been emboldened to perform in such unfroglike ways by watching too many surrounding marsupials, for the kangaroo's undeveloped, almost larval joey also must endure a slow and tortuous crawl to the parental pouch!)

In a kind of intermediate mode, some frogs brood their young internally but use structures already available for other purposes. I have already discussed *Rhinoderma,* the vocal-pouch brooder of Chile. Evolution seizes its opportunities. The male vocal pouch is roomy and available; in a context of strong pressure for brooding, some lineage will eventually overcome the behavioral and structural obstacles to grasp this ready possibility. The eggs of *R. darwini* develop for twenty-three days before the tadpoles hatch. For the first twenty days, tadpoles grow within eggs exposed to the external environment. But tadpoles then begin to move, and this behavior apparently triggers a response from the male parent. He then takes the advanced eggs into his vocal pouch. They hatch there three days later and remain for fifty-two days until the end of metamorphosis, when the young emerge through their father's mouth as perfectly formed little froglets. In the related species *R. rufum,* muscular activity begins after eight days within the egg, and males keep the tadpoles in their vocal sacs for much shorter periods, finally expelling them, still in the tadpole stage, into water (see article by K. Busse, *Copeia,* 1970, p. 395).

In this context, *Rheobatrachus* is less

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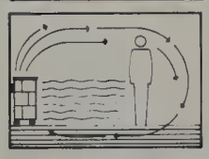

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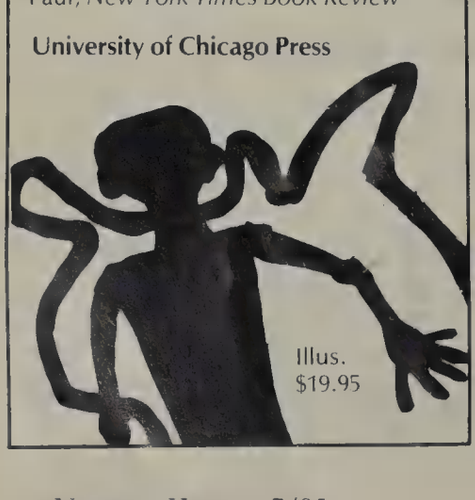

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an oddity than a fulfillment. Stomachs provide the only other large internal pouch with an egress of sufficient size. Some lineage of frogs was bound to cotton on to this possibility. But stomachs present a special problem not faced by vocal sacs or novel pouches of special construction—and we now encounter the key dilemma that will bring us back to mimicry in butterflies and the evolutionary problem of incipient stages. Stomachs are already doing something else—and that something is profoundly inimical to the care and protection of fragile young. Stomachs secrete acid and digest food—and eggs and tadpoles are, as they say down under, mighty good tucker (food).

In short, to turn a stomach into a brood pouch, something must turn off the secretion of hydrochloric acid and suppress the passage of eggs into the intestine. At a minimum, the brooding mother cannot eat during the weeks that she carries young in her stomach. This inhibition may arise automatically and present no special problem. Stomachs contain "stretch receptors" that tell an organism when to stop eating by imposing a feeling of satiety as the mechanical consequence of a full stomach. A batch of swallowed eggs will surely set off this reaction and suppress further eating.

But this fact scarcely solves our problem—for why doesn't the mother simply secrete her usual acid, digest the eggs, and relieve her feeling of satiety? What turns off the secretion of hydrochloric acid and the passage of eggs into the intestine?

Tyler and his colleagues immediately realized, when they discovered gastric brooding in *Rheobatrachus*, that suppression of stomach function formed the crux of their problem. "Clearly," they wrote, "the intact amphibian stomach is likely to be an alien environment for brooding." They began by studying the changes induced by brooding in the architecture of the stomach. They found that the secretory mucosa (the lining that produces acid) regresses while the musculature strengthens, thus converting the stomach into a strong and chemically inert pouch. Moreover, these changes are not "preparatory"—that is, they do not occur before a female swallows her eggs. Probably, then, something in the eggs or tadpoles themselves acts to suppress their own destruction and make a congenial place of their new home. The Australian researchers then set out to find the substance that suppresses acid secretion in the stomach—and they have apparently succeeded.

P. O'Brien and D. Shearman, in a series of ingenious experiments, concentrated water that had been in contact with developing *Rheobatrachus* embryos to test for a chemical substance that might suppress stomach function in the mothers. They dissected out the gastric mucosa (secreting surface) of the toad *Bufo marinus* (*Rheobatrachus* itself is too rare to sacrifice so many adult females for such an experiment) and kept it alive in vitro. They showed that this isolated mucosa can function normally to secrete stomach acids and that well-known chemical inhibitors will suppress the secretion. They then demonstrated that water in contact with *Rheobatrachus* tadpoles suppresses the mucosa, while water in contact with tadpoles of other species has no effect. Finally, they succeeded in isolating a chemical suppressor from the water—prostaglandin E_2. (The prostaglandins are hormonelike substances, named for their first discovery as secretions of the human prostate gland—though they form throughout the body and serve many functions.)

Thus, we may finally return to mimicry and the problem of incipient stages. I trust that some readers have been bothered by an apparent dilemma of illogic and reversed causality. The eggs of *Rheobatrachus* must contain the prostaglandin that suppresses secretion of gastric acid and allows the stomach to serve as an inert brood pouch. It's nice to know that eggs contain a substance for their own protection in a hostile environment. But in a world of history—not of created perfection—how can such a system arise? The ancestors of *Rheobatrachus* must have been conventional frogs, laying eggs for external development. At some point, a female *Rheobatrachus* must have swallowed its fertilized eggs (presumably taking them for food, not with the foresight of evolutionary innovation)—and the fortuitous presence of prostaglandin suppressed digestion and permitted the eggs to develop in their mother's stomach.

The key word is *fortuitous*. One cannot seriously believe that ancestral eggs actively evolved prostaglandin because they knew that, million of years in the future, a mother would swallow them and they would need some inhibitor of gastric secretion. The eggs must have contained prostaglandin for another reason or for no particular reason at all (perhaps just as a metabolic byproduct of development). Prostaglandin provided a lucky break with respect to the later evolution of gastric brooding—a historical precondition fortuitously available at the right moment, a sine qua non evolved for other reasons and pressed into service to initiate a new evolutionary direction.

Darwin proposed the same explanation

r the initiation of mimicry—and as a neral solution to the old problem of in-pient stages. Mimicry works splendidly s a completed system, but what gets the rocess started along one potential path-ay among many? Darwin argued that a imicking butterfly must begin with a ight *and fortuitous* resemblance to its odel. Without this leg up for initiation, ne process of improvement to mimetic erfection cannot begin. But once an acci-ental, initial resemblance provides some ight edge, natural selection can improve ne fit from imperfect beginnings.

Thus, Darwin noted with pleasure ates's demonstration that mimicry al-ays arose among butterflies more prone o vary than others that never evolve mi-netic forms. This tendency to vary must e the precondition that establishes fortu-ous initial resemblance to models in ome cases. "It is necessary to suppose," Darwin wrote, that ancestral mimics "ac-idently resembled a member of another nd protected group in a sufficient degree o afford some slight protection, this hav-ng given the basis for the subsequent ac-uisition of the most perfect resem-blance." Ancestral mimics happened to esemble a model in some slight degree—nd the evolutionary process could begin. The eggs of *Rheobatrachus* happened to ontain a prostaglandin that inhibited gas-ric secretion—and their mother's stom-ch became a temporary home, not an en-gine of destruction.

New evolutionary directions must have uch quirky beginnings based on the fortu-tous presence of structures and possibil-ties evolved for other reasons. After all, in nature, as in human invention, one cannot prepare actively for the utterly unex-pected. Gastric brooding must be an ei-ther-or, a quantum jump in evolutionary potential. As Tyler argues, what interme-diary stage can one imagine? Many fishes but no frogs) brood young in their mouths—while only males possess throat pouches, but only female *Rheobatrachus* broods in its stomach. Eggs can't develop halfway down the esophagus.

We glimpse in the story of *Rheobatra-chus* a model for the introduction of cre-ativity and new directions in evolution (not ust a tale of growing bigger or smaller, fiercer or milder, by the everyday action of natural selection). Such new directions, as Darwin argued in resolving the problem of incipient stages, must be initiated by fortuitous prerequisites, thus imparting a quirky and unpredictable character to the history of life. These new directions may involve minimal changes at first—since the fortuitous prerequisites are already present, though not so utilized, in ances-tors. A female *Rheobatrachus* swallowed its fertilized eggs, and a striking new be-havior and mode of brooding arose at once by virtue of a chemical fortuitously present in eggs and by the automatic ac-tion of stretch receptors in the stomach. Such minimal changes are pregnant with possibilities. Most probably lead nowhere beyond a few oddballs—as with *Rheoba-trachus*, probably already well on its way to extinction.

But a few quirky new directions may become seeds of major innovations and floods of diversity in life's history. The first protoamphibian that crawled out of its pond has long been a favorite source of evolutionary cartoon humor. The captions are endless—from "see ya later as alli-gator" to "because the weather's better out here." But my favorite has always been "here goes nothing." It doesn't hap-pen often, but when nothing becomes something, the inherent power of evolu-tion, normally an exquisitely conservative force, can break forth. Or, as Reginald Bunthorne proclaims in Gilbert and Sullivan's *Patience* (which evolution must have before all else): "Nature for restraint too mighty far, has burst the bonds of art—and here we are."

Stephen Jay Gould teaches biology, geol-ogy, and the history of science at Harvard University.

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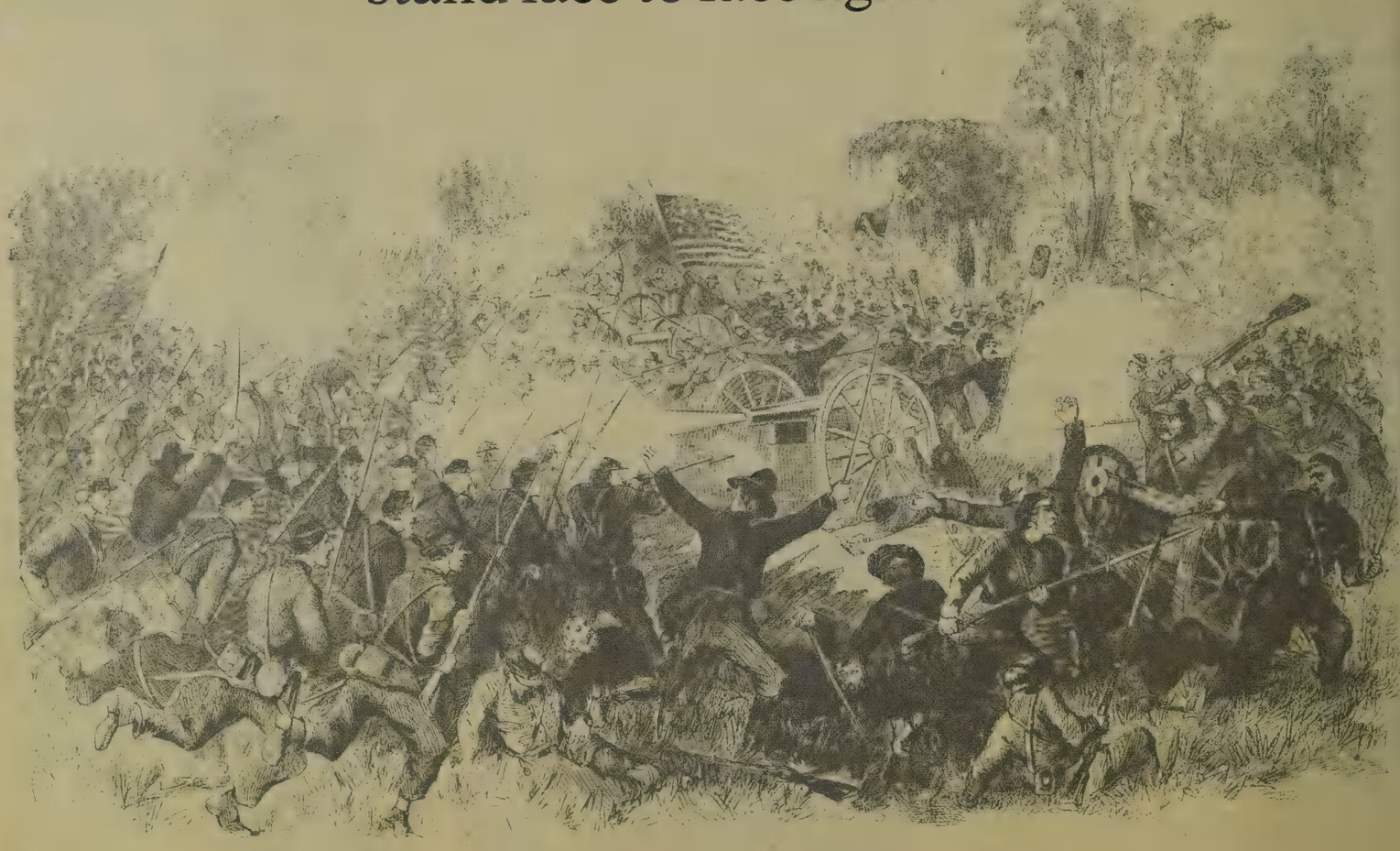

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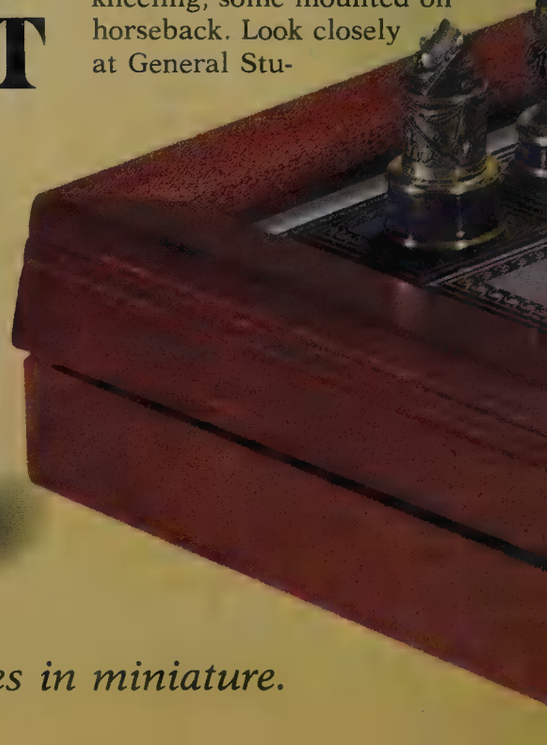

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This Land

Douglas Gruenau

Alpine Garden, New Hampshire

by Robert H. Mohlenbrock

When he stood atop New Hampshire's Mount Washington, P.T. Barnum remarked, "This is the second greatest show on earth." Highest of the eleven peaks that make up the Presidential Range, Mount Washington lies in the heart of White Mountain National Forest. The 6,288-foot summit extends well above the region's tree line, and bleak tundra covers nearly eight square miles of the surrounding territory. Here, one thousand feet down and east of the mountaintop, is a natural area known as the Alpine Garden. Two-thirds of the garden's 110 kinds of flowering plants are alpine species whose major range is far to the north. Many plant species that live here are more common in Labrador, Newfoundland, and areas in the Arctic. Alpine azalea, moss cassiope, mountain heath, alpine bearberry, and two eyebrights range from Newfoundland and the mountains of Quebec south only to the Presidential Range. Alpine bluet grows just on the islands of Saint Pierre and Miquelon and on Mount Washington.

There are three ways to reach Mount Washington's summit and the adjacent Alpine Garden. For the nostalgic, a cog railroad makes the climb to the top in seventy minutes, as it has since 1869. The eight-mile automobile toll road takes a more circuitous route. The third way to go is to hike one of the several trails. As a botanist, I prefer the last method because it affords a close look at a variety of habitats en route.

It was a crisp and sunny late June morn-

ing when I hiked away from Pinkham Notch toward Tuckerman Ravine, on the eastern flank of Mount Washington. But at about 4,800 feet, I left the ravine forest and came out into the open, where sharp gusts of bone-chilling wind nearly took my breath away, and a heavy, wet fog hovered above me. I felt as if I had been translocated into the Arctic, and the types of plants around me contributed to the illusion. I had broken into the krummholz—"crooked wood," in German—that zone of gnarled dwarf trees a few hundred feet below the treeless tundra. Because of the fierce climate, which reduces the rate of photosynthesis, black spruces and balsam firs are only a few feet tall, despite their considerable age. Frigid and furious winds prune away all branches of these hardy plants that protrude above the layer of winter snow.

At about 5,100 feet, I passed the last of the krummholz plants, and the solemn-looking, rock-strewn slope of the Alpine Garden lay ahead. The garden surface has been shaped by frost through the centuries. Permanent moisture and fluctuating low temperatures have created the subsurface soil known as permafrost, which has remained frozen for thousands of years. Above the permafrost is a layer of water-saturated soil that repeatedly freezes and thaws, heaving rocks and pebbles out of the ground. Sometimes the rocks are deposited in rings and polygons, sometimes in small piles. In places, thawing, saturated soil creeps downslope over bedrock (a process known as solifluction), eventually forming very low, undulating ridges called solifluction terraces.

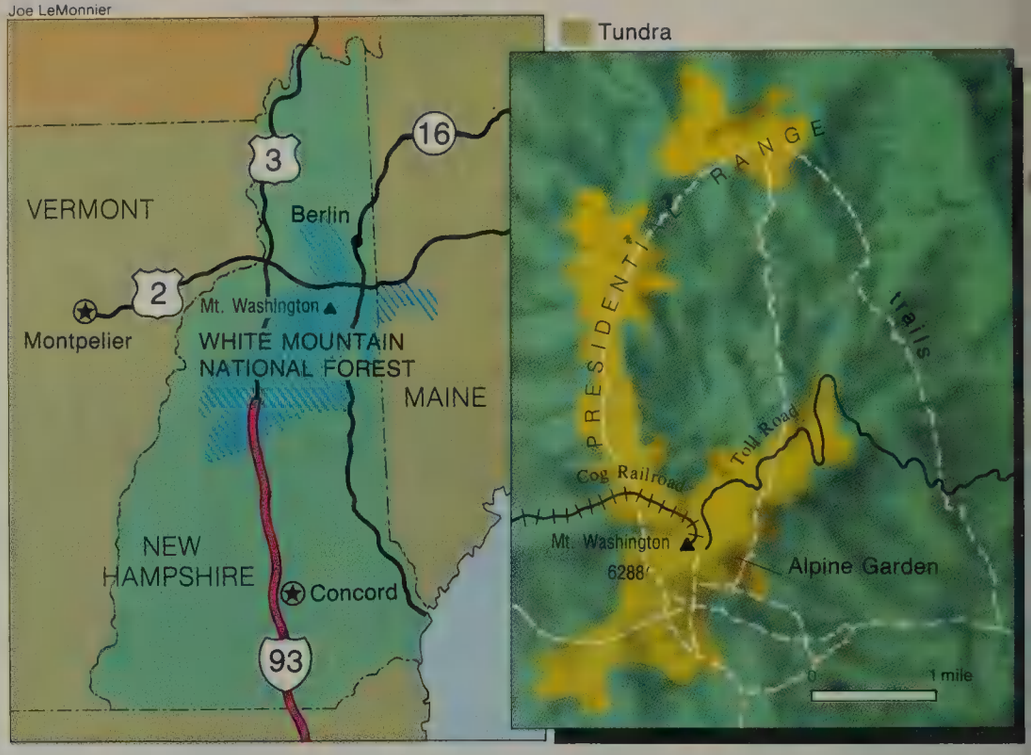
Plants in the Alpine Garden contend with bitter conditions. The mean annual temperature on the tundra is only 27 degrees Fahrenheit, with July the warmest month at 48 degrees. The winds surpass 100 miles per hour every month of the year, with a world high of 231 miles per hour recorded in 1934. Clouds block out the sun about 75 percent of the time, mostly in the form of wet fog, especially on the western slopes. Winter snow piles up an average 195 inches; during the winter of 1957–58, 344 inches fell on Mount Washington.

The plants that have adapted to life in the tundra make the most of the natural features. Something as seemingly unimportant as the lee side of a rock may give just enough protection for a seedling to grow into a mature plant. The nearly imperceptible ridge of a solifluction terrace may provide the right exposure to the sun for seeds to germinate and develop. Snowbanks built up by the freezing, hurricane-force winds insulate the parts of plants that otherwise would perish during the winter. Natural springs from high up on Mount Washington flow out across the Alpine Garden in clear, cold streams, offering the bordering plants the water they need to complete their life cycle during the short growing season.

Most plants on Mount Washington are perennials, with taproots that penetrate more than a foot into the soil. Because they have a stable root system, they needn't perpetuate themselves every year by flowering and forming fruit and seed. If the conditions are especially harsh, a plant need only form a few new leaves to replenish its supply of stored food.

Since the growing season in the Alpine Garden seldom lasts more than one hundred days, plants begin their life cycle as early as possible. The three-toothed cinquefoil, for example, begins to flower as soon as the temperature climbs above freezing. The flower buds in such species are formed during the previous season and kept safely protected by surrounding tissues over the winter.

Joe LeMonnier



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Thai

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To avoid the intensity of the wind, most alpine plants are very short, and often they are plastered against the ground. While most willows are upright trees or shrubs, the Alpine Garden's bearberry willow grows in dense mats only two inches high. Other plants, like the diminutive moss campion, have branches tightly woven into a rounded cushion that surrounds a deep taproot. At the center of the cushion, where the branches and leaves are densely packed, the temperature is warmer than in the surrounding environment. The threat of desiccation is also minimized, because the wind tends to blow over the rounded form.

Small, compact leaves, like those of the moss cassiope, are common in alpine species because they require less energy for their maintenance. Plants with grasslike leaves, such as sedges and rushes, are also prominent members of the alpine flora. Their slender leaves are less likely to be shredded by the strong winds. Occasional patches of sphagnum, or peat moss, as well as a few other plants, are colored by anthocyanin, a reddish blue pigment. Anthocyanin absorbs rays of light, helping to keep plant tissues warm.

Although at first the Alpine Garden appears uniform, discrete plant communities can be recognized. On most of the slopes that grade down to the level terraces, clumps of alpine rush are surrounded by lower, compact growth of mountain cranberry and bog bilberry, two heaths with pink bell-shaped flowers and small, leathery leaves. By late July, the mountain cranberry forms bright red acidic berries, while the bilberry bears sweet, black fruit. Other plants in this community include the mountain sandwort, whose bright white flowers enliven the landscape. The sandwort's penchant for growing along the edges of trails makes hiking in the dense fog somewhat easier.

In shallow depressions, and on the lee side of rock piles, a dwarf shrub heath community often develops. Low sweet blueberry, Labrador tea, and the alpine bearberry, as well as the mountain cranberry and bog bilberry, form dense mats as much as twelve inches deep. Within the boundaries of rock polygons, solid masses of diapensia often grow so densely that they prevent other flowering plants from becoming established. Diapensia is a cushion plant that resembles members of the heath family except for its flowers.

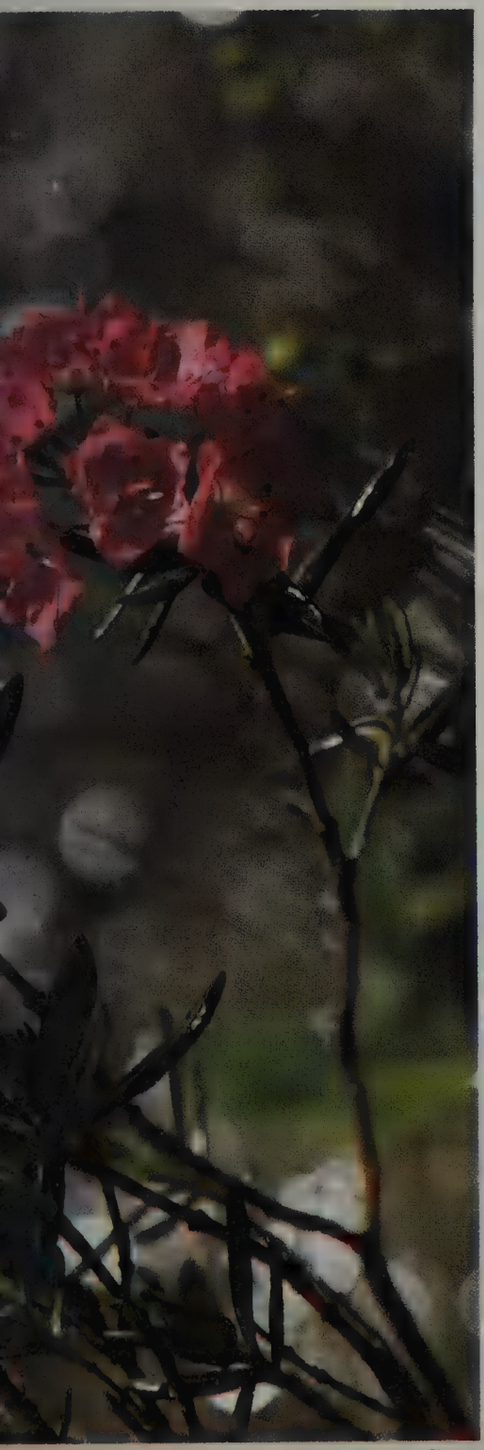
The streams that radiate across the Alpine Garden are lined with dark green bands of vegetation. The streamsides are the most interesting of the plant communities because they contain a diversity of species. One is the tea-leaved willow, which looks like a normal willow in miniature, having a stature of no more than two feet. Another curious plant, the alpine bistort, forms several pale pink flowers, but none of the flowers set seed. Instead, tiny balls of plant tissue, called bulblets, develop below the base of the flowers. After dropping to the ground, the bulblets can grow into new plants without benefit of pollination and fertilization.

The range of some of its alpine species sets the Alpine Garden apart from similar habitats elsewhere in New England. At one time scientists thought that arctic plants reached the White Mountain region when they ranged southward in advance of continental glaciation. In this view, Mount Washington and adjacent peaks became areas of refuge as the glaciers marched past at lower elevations.

Pale laurel is an alpine heath.

owever, glacial till has been discovered
the mountain summits, showing that
ey too were covered over. Biologists
eculate that the arctic plants found a ha-
n farther south and migrated into the
ea as the glaciers began to recede.
I was only able to stay about two hours
my first visit to the Alpine Garden be-
use the weather was nearly unbearable.
n a subsequent trip, however, the fog
as gone and the winds were moderate.
he view was spectacular. It must have
een on such a day that P.T. Barnum
ood atop Mount Washington.

This Land" highlights the biological henomena of the 153 U.S. national for-ts. Robert H. Mohlenbrock is distin-uished professor of botany at Southern linois University at Carbondale.



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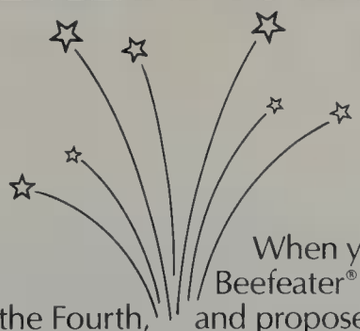

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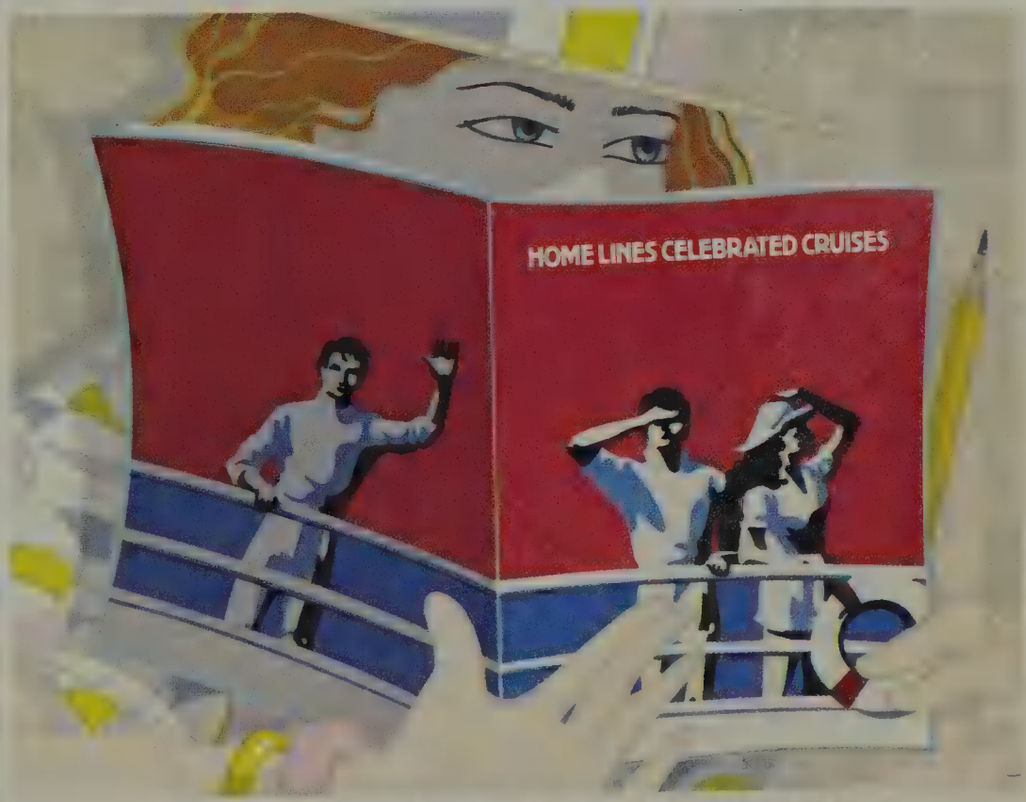

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A rocky outcrop protects a clump of sky pilots from high alpine winds.

Frank J. Staub

The Smell of Success

As a little wildflower in the Rocky Mountains discovered, it sometimes pays to make yourself unattractive

by Candace Galen

For poets, the sweet fragrances of flowers have long served as symbols of purity and happiness. Perfume manufacturers have more worldly interests; they have created a lucrative industry built on the recognition that fragrances are powerful attractants. Evolutionary ecologists, too, have been inspired by floral scents, which seem to so neatly serve the interests of both plants and their pollinators.

But do floral scents simply signal the presence of pollen or nectar to foraging birds and bees? In many flowering plants, the answer appears to be yes. Some plants—the blueberry, for example—produce scented compounds in the nectar itself, where they may actually be perceived as flavoring by the bees that pollinate the flowers. But the scent that attracts pollinators may emanate from another part of the flower entirely. Furthermore, other floral smells appear to play no role in attracting potential pollinators. Why would any plant evolve such a seemingly useless and chemically costly trait? Clearly, the role of floral fragrance is more complicated than it appears at first glance, and this is where the evolutionary ecologist can make a contribution.

In late June, the snow cover of alpine Colorado begins to recede, exposing a carpet of cushion plants, forbs, willows, and grasses. The stature of these plants, like the twisted forms of the bristlecone pines only a few steps below, testifies to the presence of constant, often buffeting winds. Here, on the slopes of the Rockies, grows an unusual member of the phlox family: *Polemonium viscosum*. Better known as sky pilot because its dense flower cluster rises like a periscope above the alpine tundra, this wildflower is a particularly interesting one from the point of view of floral fragrance: some sky pilot flowers produce a sweet smell; others are distinctly skunky. Occasionally flowers of a single plant have both scents, but usually the skunky smell masks the sweet one.

The two scents of sky pilot flowers possess some markedly different chemical characteristics. Interestingly, they are also produced at different sites within the flower. As an evolutionary ecologist, I was curious to know what forces led to the exis-

Below: The fragrance of a sweet-scented sky pilot emanates from deep within the center of each violet blue flower. The odor of skunky flowers comes from sticky hairs on the small green leaves encircling each blossom. The green leaves enclosing flower buds may also have a skunky smell. Right: Unlike bumblebees—which are faithful to one flower species—flies are fickle and inefficient pollinators. The fly on this alpine avens blossom may be depositing pollen picked up on a sky pilot.

Bob Rozinski

tence of the two scent variants, or morphs, in this species, and I spent five summers of fieldwork in central Colorado trying to find out.

To my initial surprise, many of the people I met in the course of my research spoke of encounters with the skunky morph of the sky pilot but were not familiar with the sweet one. Similarly, leafing through herbarium sheets at Colorado State University and the University of Colorado at Boulder, I found several reports of floral scent in *P. viscosum,* and nearly all alluded to skunkiness. Yet both variants commonly occur together, and extensive stands of plants with sweet-scented flowers grow on the tundra near Independence Pass and next to Rocky Mountain National Park's well-traveled Trail Ridge Road.

I soon began to understand the reason for the common perception that sky pilot always smells skunky. In my study area west of the town of Fairplay on Pennsylvania Mountain, I found that plants with skunky-scented flowers were most abundant at more accessible, lower sites in the krummholz (the area of stunted, dwarfed trees found at timberline), whereas those with sweet-scented flowers were increasingly common at higher elevations, on the slopes of the upper tundra. Thus, hikers who take time to smell the flowers are likely to encounter the unpleasant morph first, and since the two variants look identical, they probably avoid sampling sky pilot higher up on the trail.

I suspect that botanists also tend to record unusual features, such as skunky scent, while accepting with little fanfare the sweet fragrances that flowers are assumed to have. I, too, might have missed the sweet-smelling sky pilots if Peter Kevan—then at the University of Colorado at Colorado Springs and now at the University of Guelph in Ontario—had not introduced me to flowers of both scents on my first tour of Pennsylvania Mountain. Later, reading through my sun-bleached copy of William Weber's field guide to the Rocky Mountain flora, I was pleased to find much attention paid to floral variation, including a description of scent differences in *P. viscosum.*

Each sky pilot plant usually bears eight to twelve tightly packed flowers, pollinated by insects. Flowers consist of a fused ring of small, green sepals encircling a funnel-shaped corolla of violet blue petals. Inside is a whorl of five bright orange, pollen-bearing anthers. The ovary sits upon the base of the corolla, on a disk of tissue that secretes nectar. In a sweet-scented flower, fragrance emanates from this area and becomes detectable when the flower opens. The scent of skunky flowers is not associated with the nectary; it appears to be a product of the sticky hairs on the outer surface of the sepals and is present in the bud and fruit, as well as the blossom. Chemical studies have shown that the sepals of skunky-scented flowers contain a much broader spectrum of volatile chemicals than those of sweet ones. But to un-

Kent and Donna Dannen

derstand how these two fragrances function, I needed to look beyond chemistry. To get a clearer picture, I decided to study the characteristics of the various insects attracted to flowers of each scent.

In a very general sense, the livelihood of all flower-visiting insects depends on their skill in distinguishing flowers on the basis of such features as form, color, texture, and scent. A bee, for example, may use form to spot appropriate plants from a distance but depend on fragrance to identify particularly attractive flowers from close up. Plants with desirable flowers may benefit from the bee's visit by receiving more pollen and ultimately producing more viable seeds than those with rejected flowers. Because seed production, which botanists call seed set, is an intrinsic part of a plant's fitness (the more seeds, the more potential offspring), bees and other pollinators may act as agents of natural selection. By exercising their floral preferences, they shape the evolution of flower traits in the plants they service.

Not all insects have the same effects on a plant's reproductive fitness, however. The insects that visit flowers are a diverse lot. Bumblebees, solitary bees, syrphid flies, anthomyiid flies, muscid flies, and ants are all commonly found on flowers of *P. viscosum*. Yet their feeding activities at these flowers differ markedly. Bumblebees and ants imbibe nectar, syrphid flies and solitary bees gather both nectar and pollen, and shorter-tongued anthomyiid and muscid flies collect only pollen. Except for ants, all of these insects carry some pollen grains from one plant to another, and since sky pilot requires such outcrossing to set full seed, a visit from any of these insects can be valuable. But from the plant's perspective, some visitors are more beneficial than others. The insect's size, posture, and behavior may make an important difference. The sky pilot's stigma—the sticky, pollen-receiving tip—sticks out slightly beyond the center of the corolla opening. A gap of about five millimeters separates it from the pollen-bearing anthers. Pollen-gathering flies that alight on the flowers are small and can feed on the anthers without brushing against the stigma; thus they remove pollen but seldom deposit any. Flies are also fickle; they are as apt to move onto neighboring cinquefoil or avens flowers as to go from blossom to blossom of *P. viscosum*. In such a case, the sky pilot pollen may be lost before reaching its destination.

In contrast, bumblebees, especially the large, burly queens of *Bombus kirbyellus*, are well suited to transfering pollen among sky pilot plants. A bumblebee queen probing the nectary at the base of the corolla receives a dusting of pollen on her face and thorax. And unlike flies, individual bumblebees are faithful to one species, and, at least within single foraging trips, rarely sample more than one kind of flower. A foraging queen may carry hundreds of *P. viscosum* pollen grains at any time. As she moves systematically from flower to flower, she may leave ten to fifty grains on the stigma of each flower visited. Bumblebees serve the host plant well.

Some of the wildflower's insect visitors are not beneficial at all, however. These, in the words of nineteenth-century naturalist Aubrey Kerner, are "unbidden guests," typically stealing nectar or pollen without causing pollination. Ants are notorious for this kind of behavior. In Colorado, the common alpine ant, *Formica neorufibarbus gelida*, depends on flower nectar as a major source of food. In 1979 and 1981, more than a fourth of the sky pilot plants I examined had been parasitized by these nectar-stealing ants. In their efforts to reach the nectar-producing disks, the ants damage the ovaries and sever the slender styles at the base, causing them to drop from the flowers. Accordingly, seed set in ant-damaged flowers is negligible.

I found that I could prevent damage of this kind by coating the plant stems with

rings of Tanglefoot, a sticky substance that foresters use to keep insects from attacking tree wounds. Knowing that some plants of tropical and temperate areas have developed elaborate barriers, ranging from thickened bracts to sticky exudates, to keep ants from their inner floral tissues, I wondered if all *P. viscosum* plants were equally susceptible to ants or if some had developed natural Tanglefoot-like barriers. In particular, I wondered if the unusual scent variation found in this species might be related to such a barrier. To answer this and other questions about sweet- and skunky-scented flowers, I looked in greater detail at the insects visiting the sky pilot in the krummholz and tundra environments.

Whether walking through the stubby growth of the krummholz or on the open tundra slopes, summer hikers on Pennsylvania Mountain may hear the low-pitched buzzing of active bumblebees, notice flies basking on sun-warmed blossoms, and pause to brush ants off of their wool socks. Looking more closely—following bees on their foraging trips, for example—will reveal slight differences in the two environments.

In the krummholz, sky pilot blooms in late June, when thousands of willow catkins are also flowering. Attracted to the tiny droplets of nectar glistening on the willow flowers, bumblebees only occasionally visit any other type of flowers, including sky pilot. In this area, sky pilot appears to depend largely on flies and solitary bees for pollination. Interestingly, however, if plants are surrounded by cages that permit the smaller insects to enter but exclude bumblebees, their seed set drops to about half that of uncaged neighbors. Apparently, close to half the seeds produced by flowers in the krummholz result from only a few bumblebee visits, attesting to

Kent and Donna Dannen

Left: In the Rocky Mountains, a single field may contain both sweet- and skunky-scented sky pilots. At lower elevations, skunky-scented plants are more common, leading many hikers to the misperception that the species always has an unpleasant smell. Below: Like the hikers, bumblebees avoid skunky sky pilots. Consequently, such plants are more often visited by pollen-gathering insects, such as this fly. These insects are often so small that they may feed on the orange anthers without depositing any pollen on the sticky white stigma just five millimeters away.

Kent and Donna Dannen

he remarkable effectiveness of bumble-ees as pollinators of *P. viscosum.*

The situation is even more dramatic on he tundra. There, similar screening re-ults in a tenfold decrease in seed produc-ion. Few willows grow on the tundra, and he bumblebee queens gather nectar al-most exclusively from *P. viscosum*, at east early in July, when the species is in loom at high elevations. Flies on the tun-ra prefer to feed on the flat yellow flow-rs of the alpine avens and so have little ef-ect on the seed set of the sky pilot plants rowing there.

Ants, like flies, are most common on sky pilots at relatively low altitudes. While the alpine ant tolerates cold better than any other ant in Colorado and has been found at 14,100 feet, it is much more abundant lower down, in the subalpine. On Pennsylvania Mountain, ants are common in flowers of *P. viscosum* from the krummholz to just over 11,800 feet on the eastern slopes, and about four plants in ten have flowers damaged by ant visits. At sites above 12,800 feet, near the summit, only about one plant in ten has damaged flowers.

Thus, both the number of insects and the proportion of sweet to skunky sky pilots on Pennsylvania Mountain vary to some extent with elevation. Plants with sweet-scented flowers are most common on the tundra, where bumblebee pollination is the rule, and at least on the upper slopes, ants rarely parasitize blossoms. Conversely, plants with skunky-scented flowers dominate in the krummholz, where they are more likely to be damaged by ants and where pollination is often effected by flies and solitary bees. When I discovered this pattern, I thought it suggested a relationship between the abundance of different kinds of flower visitors and the success of the two floral morphs. But to predict the form that this relationship might take, I needed to learn the insects' scent preferences. Therefore, during several of the summers I spent on Pennsylvania Mountain, I watched flies, solitary bees, and bumblebees in flight, keeping track of each kind of insect in the environment where it was most common and recording the number of times that each forager chose sweet- or skunky-flowered plants. In the krummholz, most flies and solitary bees appeared equally likely to frequent sweet- or skunky-scented blossoms, with the result that the two kinds of flowers received about the same number of visits from these pollinators. Only the anthomyiid and muscid flies, the least adept of available pollinators, showed any preferences, visiting skunky flowers twice as often as expected.

On the tundra, a somewhat different pattern emerged. At the elevation where my observations were made, plants with sweet-scented flowers were twice as common as those with skunky ones, yet bumblebees chose sweet plants more than six times as often as their skunky neighbors. Since both variants secrete about the same amount of nectar, I was surprised to find bumblebees actually avoiding plants with skunky flowers and visiting, instead, more distant, sweet-smelling flower heads. Perhaps the skunky scent confuses or repels the bees. Alternatively, sweet scent might guide them to the nectary, reducing

Jeff Foot

Sky pilot shares its alpine environment with many other kinds of wildflowers, including alpine sunflower, chiming bell, yellow paintbrush, avens, and cinquefoil.

Kent and Donna Dannen

the time spent locating and removing nectar in each flower. If so, the energetic costs of visits to sweet-scented flowers would be lower than visits to skunky ones. Finding the right answer requires asking more questions and studying the bees' foraging behavior in more detail, a course I hope to pursue in the future. Regardless of which rule bees follow in rejecting skunky-flowered plants, however, their preference is clear, and it is likely to have important consequences for the relative success of the two floral morphs on the tundra, where bumblebees account for 90 percent of the pollination that plants receive.

My next query concerned the ants' scent preferences. During 1979 and 1981, I monitored ant activity in the krummholz by keeping track of an exclusive trademark of ant parasitism: flowers with missing styles. In both years, more than half the plants with sweet-scented flowers in my census area had some of their blossoms damaged by ants. Floral parasitism of neighboring skunky-flowered plants was much less common. Ants, like their distant relatives the bumblebees, prefer the sweet morph. A simple experiment suggested why. Ants placed gently on stems of sweet-flowered plants crawl upward over the sepals into the open flowers. Placed on skunky-flowered plants, most ants get as far as the bases of the sepals and then retreat down the stems. Evidently, they are repelled by the viscous skunky substance coating the sepal hairs. Moreover, as I found when I conducted further experiments, skunky scent alone can invoke retreat.

If skunkiness is so unpopular, why does it persist? In essence, depending on the environment, the benefit that comes from avoiding flower parasites may outweigh that of attracting the best pollinators. The results of two additional field experiments provided further support for the idea that the predominance of skunky-scented plants in the krummholz and of sweet-scented ones on the tundra is due, at least in part, to the changing balance of bumblebee and ant visits.

On the tundra, I cross-pollinated flowers on several plants, both sweet and skunky, growing just below the summit of Pennsylvania Mountain. Flowers on neighboring plants were left alone and received only natural pollination. As expected in an environment where ant damage is minimal and bumblebees account for most of the pollination, naturally pollinated sweet-scented flowers contained about one and a half times as many seeds as their skunky-scented counterparts. However, regardless of scent, all the flowers that received extra hand pollination produced large numbers of seeds. Accordingly, on the high tundra, skunky-flowered plants appear to be at a disadvantage, but it is not due to any intrinsic inability to set seeds—they are simply less attractive to the all-important bumblebees.

Farther down the mountain in the krummholz, I painted Tanglefoot around the stems of randomly chosen sweet-flowered and skunky-flowered plants. Later, I harvested the dry fruit capsules of these as well as other, unprotected neighboring plants. Counting the seeds, I found that ants had little effect on seed set of plants with skunky-scented flowers. In contrast, protecting sweet-flowered plants more than doubled their seed production.

Surprisingly, though, even when sweet-flowered plants were protected from ants, they were not guaranteed the same seed set as their skunky-flowered neighbors in the krummholz. In some locations, th morphs had equal seed set in the absenc of ants, but in others, plants with skunk flowers continued to set more seeds. Thes results suggest that other factors—per haps the pollinating activity of flies or in trinsic physiological differences betwee the two morphs—may come into play i determining morph abundance in lowe elevations. Still, the experiment showe clearly that under conditions in which th floral morphs might otherwise do equall well, damage from nectar-stealing ants likely to cause the seed set of sweet-flow ered plants to fall well below that of the skunky-flowered neighbors. In those env ronments, ants act as agents of natural se lection, favoring the persistence of skunk sky pilots.

Pennsylvania Mountain is certainly no the only spot where the availability of po linators and flower parasites varies, an the sky pilot is unlikely to be the onl flower in which a sweet scent sometime proves to be a liability. Seen in this ligh differences within or among plant specie in such flower features as chemistry, odo and even form might be better evaluate as responses not only to the senses an preferences of pollinators but to those parasites and predators as well. The sme of success is not always sweet.

Maori Images

To the Maori, photographs are both sacred and profane

by Michael King

In 1968, when I began research on traditional tattooing among the Maori of New Zealand, I became aware that Maori attitudes toward photography differed sharply from European ones. In the course of my project I brought a photograph of a deceased woman with a chin tattoo to another woman, Makere Hose, for identification. Mrs. Hose held the framed portrait for a long time, staring at it. She began to cry, silently at first, then aloud. After about ten minutes she stood the picture on a shelf in her living room and began to talk to the deceased woman in Maori. "Ah. It's a long time since we've been able to look at each other. It's a long time since we've been able to talk. But you seem just the same. So. You're with your mother and grandmother at last, eh?"

Despite my presence, Mrs. Hose showed no sign of self-consciousness. I had been sitting when she began her lament but rose to my feet again because it seemed disrespectful to sit through what was in effect a religious ritual. Half an hour after I had handed her the photograph, she turned to me and said: "It's Rehara. Rehara Maki. She came from Waharoa, but she attended all our *hui* [gatherings]. She died over a year ago. Her *moko* [chin tattoo] was done by Kuhukuhu."

Being inexperienced in the ways of the Maori, I was perhaps less sensitive than I would be today. I wanted to understand, and so I asked intimate questions. "You treated that photograph as if it were a living person. Why?" "Ah," said Mrs. Hose. "It's got her image, you see. And that image is her *mauri* [life force]. Whenever I see a picture of a person, I see the *mauri*, then it's alive, never mind that the person's dead."

She elaborated when I asked if I could arrange for her own photograph to be taken. "No, " she said. "You can look at me, you can look at my *moko*. But you can't photograph it. Because if you do that you are taking away some of my *mauri*. And when that happens people lose their spiritual protection, and they are diminished. If it happens too much, they die, like Rehara here. I don't want that to happen to me."

Shortly after talking to Mrs. Hose, I took a photographer to the village of Honikiwi to a woman who *was* prepared to be photographed, a near-centenarian named Kirikino Epiha. Her portraits turned out well and highlighted her deeply chiseled chin tattoo, which was done about 1900. I sent a framed copy back to the old lady and her family as a gift of thanks. Within weeks I got news that Kirikino had died. I was unable to attend the mourning ceremony. When I finally did get back to Honikiwi, Kirikino's daughter, herself an old woman, told me an extraordinary story.

"We put your photograph at the foot of Mum's coffin, so that the mourners could see it as they arrived. As each group came up to the tent where she lay in state, the glass on the picture misted over. All except the nose. You could still see the nose." "What did that mean?" I asked, totally confused. "The misting over meant that Mum was crying with the mourners. But the fact that her nose was visible meant that she was also *hongi*-ing with them [the Maori custom of pressing noses with visitors], making them welcome."

Both these incidents introduced me to attitudes I was to encounter often among conservative Maori—those who believe in and practice Maori values—over the next fifteen years. These Maori respected photographic images to a degree that bordered on reverence; when friends or relatives died, they wanted photographs more than anything else to remember them by. But they remained apprehensive about being photographed. Old people in particular were targets for the cameras of Europeans, and since, inevitably, some of those old people died within a short time of be-

A daguerreotype of the Barrett sisters, left, taken in 1852, is the oldest surviving Maori image. The Barretts, products of an interracial marriage and living in European-style homes, were not typical Maori. Traditional Maori communities were not photographed until the development of the wet-plate method in the late 1850s.

Taranaki Museum

The village meetinghouse, below, was regarded as a repository for ancestral presences. By the late nineteenth century, photographs of the recently deceased members of a clan were being hung on the inside walls.

Ngai Tahu Archive

ing photographed, the apprehension was reinforced.

The ambivalence is strongest at Parihaka Pa in Taranaki. This community values photographs of its historic personalities and its previous buildings (it was a thriving town in the late nineteenth century) more than any other I know. Yet it also forbids bringing cameras into the village. The act of photography by non-Maori is condemned; the results of such photography are esteemed highly.

Still other factors affect Maori attitudes to photography. Some Maori fear that Europeans will profane their sacred images—such as those of revered ancestors, carved meetinghouses, or people with tattoos—by selling photographs of them for money. The considerable industry at work in New Zealand reproducing Maori images and placing them in profane contexts justifies this fear in Maori eyes. The most profane act possible is to associate sacred images with food, and this has been done frequently. Maori heads adorn tea towels and biscuit tins, and Maori portraits hang in hotel dining rooms.

The origin of these attitudes can be found in the history of photography in the area. Photography did not reach New Zealand until the late 1840s. The first method used in the then British colony was the daguerreotype, named after its inventor, Louis Daguerre. The process required lengthy exposures (at first some ten to fifteen minutes, later five to thirty seconds), was expensive (from ten shillings to two guineas per picture), and resulted in a single positive image. It could be seen only from certain angles, and it could not be duplicated. In New Zealand, early daguerreotype photography did not extend far beyond the controlled conditions of makeshift studios that were set up outside the homes of wealthier European settlers. Hence Maori portraits from this time are few and their range is narrow.

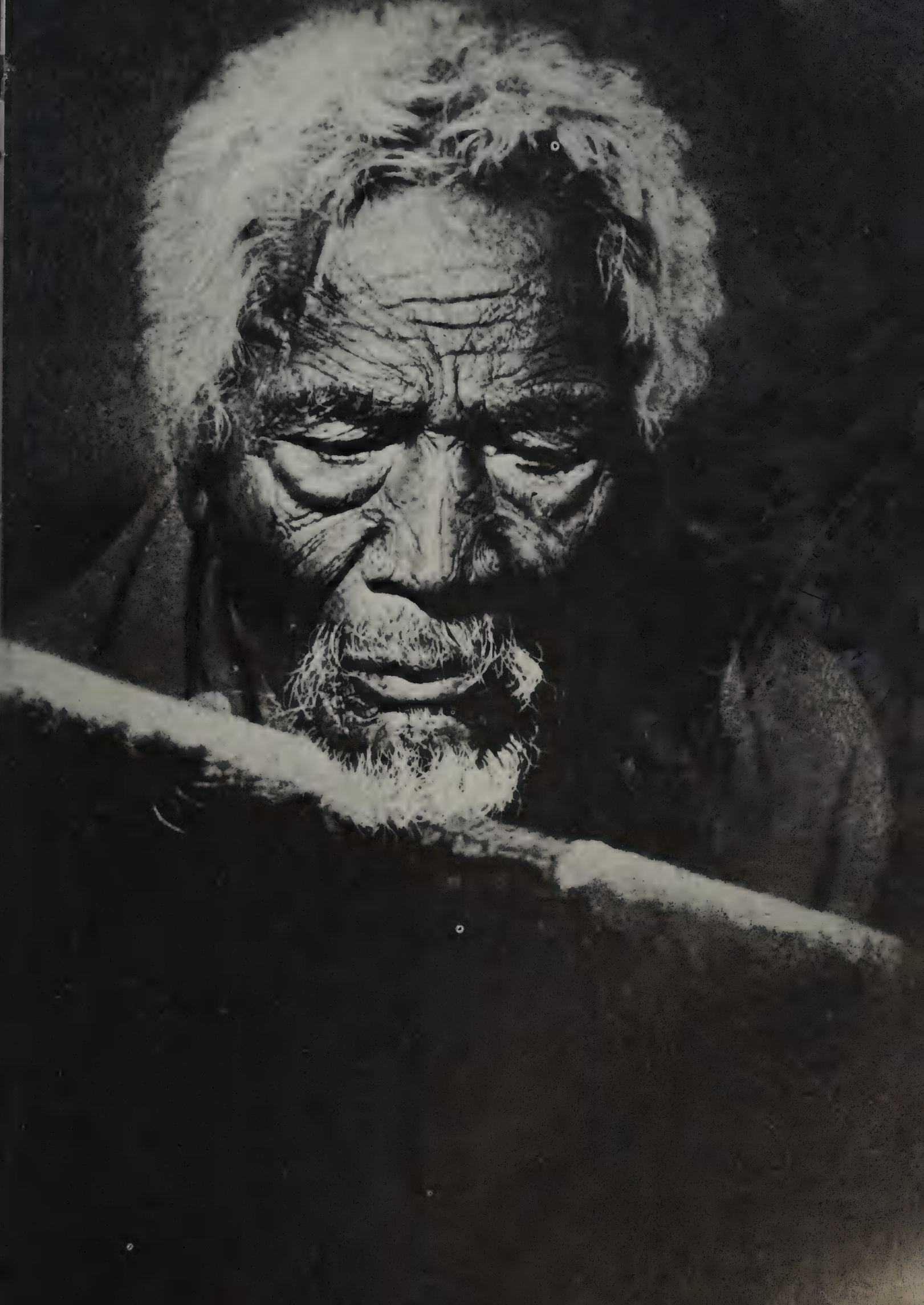
A daguerreotype of the Barrett sisters, taken in New Plymouth in 1852, is the earliest surviving Maori image. Because of the limitations of the process, the first Maori photographed were not typical—they were usually like the Barretts, products of interracial marriages who lived in European-style homes in coastal towns. It is also likely that such families shared European attitudes.

The wet-plate process introduced in the mid-1850s allowed greater flexibility. Although long exposures and studio-type conditions were still preferred, photographers could now carry equipment and chemicals into the field. The process was more versatile and became cheaper than daguerreotype photography. Multiple prints could be made from wet-plate negatives; thus more pictures went into circulation and more survived. Maori were still mostly photographed in towns, but beginning in the late 1850s, photographers began to move out into Maori communities.

In effect, from the time the Maori were first exposed to photography—in the late 1850s and early 1860s—they were ambivalent about the practice. In most cases the photographs themselves generated respect; in some instances, even awe and fear. Uninitiated to the mysteries of physics and chemistry, Maori were unlikely to understand the process. But they were well aware of its dramatic consequences: a person's image—his or her most intimate characteristic—could be captured at a given moment, frozen, reproduced, circulated, and retained for posterity, even af-

Men with facial tattoos were popular subjects for paintings and photographs, right. Because no tattooing was done on men after the 1860s, subjects were scarce by the early 1900s and no longer existed after the 1920s.

Auckland Institute and Museum



The penny-haka *(a dance performed for money to amuse tourists), below, was one of the most common subjects for picture postcards and contributed to the image of Maori as simpletons.*

Alexander Turnbull Library

ter the subject had died. In early photographs, some subjects, obviously not understanding what was happening, stare anxiously at the camera; others glare into the lens with complete confidence.

Most portraits from the late 1850s and the 1860s were taken in town studios such as that of the American Photographic Company in Auckland. John McGarrigle, who worked for the company, would go out into the streets and persuade Maori visiting the town to step inside and be photographed. Many of these pictures were used in the picture postcard trade, which flourished at midcentury. Because they suggested exotic and romantic images of frontier life in New Zealand, postcards of Maori were favorites for Europeans to send abroad.

But within Maori communities, where Maori mores prevailed, suspicion and even fear of photographers persisted. In 1885 photographer Alfred Burton reported that his Maori subjects along the Wanganui River called his camera a *taipo* (goblin). Some Maori refused to be photographed, others had to be bribed into cooperating. That same expression, *taipo*, was still applied to the camera in 1909, when George Bourne photographed the Maori of the remote Urewera district.

In Maori communities close to European ones, however, changes began to become apparent in the late 1880s. Once it occurred to Maori that they need not simply be passive subjects for European photographers, that they could order and arrange pictures for their own purposes, they began to look upon the process more favorably. At this time, and even more so in the 1890s, families began to commission individual and group portraits to hang in their own homes and in meetinghouses. Because the Maori have a strong sense of family, all photographs of relatives were highly prized.

Once the subject had died, the photographs were valued even more. From the 1890s, pictures were hung in meetinghouses (which were regarded as repositories for and representations of ancestral presences). They were used in mourning ceremonies to recall the deceased and the relatives who had died before him. Arranged around the coffin, the photographs were addressed during the funeral oratory as if they were living presences. These customs persist in the twentieth century and are a classic example of the Maori capacity to accommodate features of Western technology into a framework of Maori values, with a consequent strengthening of those values.

Today, the use of photographs to commemorate the dead is more elaborate. Pictures are used to represent the dead in ceremonies where bodies are not actually present, such as the *kawe mate* ritual, in which a death is commemorated after a burial, and at "unveilings" of tombstones. Since the 1970s photographs have even been used on the tombstones themselves.

Back at the turn of the century, however, another use of photography began to disturb Maori leaders. In the 1860s, Maori had scarcely noticed the then-popular custom of exchanging picture cards; few of them kept albums at this time. But the postcard craze of the 1890s and early 1900s did come to their attention. In 1909 the postcard trade in New Zealand reached its peak—nine million cards passed through the postal system in a country with a population of just one million. Europeans liked to send cards to fam-

This young woman's portrait, left, was commissioned by her family for its own use. The woman wears native dress and is pictured with family heirlooms, a style favored by the Maori.

National Museum

The display of photographs at mourning ceremonies, below, began in the last decade of the nineteenth century. They were used to recall the presence of the deceased and of relatives who had died previously.

Auckland Institute and Museum

ily and friends—especially picturesque or amusing cards—and the popularity of Maori images required many models. These models were photographed in contexts that bore little or no relation to the manner in which they actually lived.

The most popular cards were of old-time Maori, nostalgically depicted as the last in a line of noble warriors or priests; re-enactments of pre-European Maori scenes in spurious period costumes; scenes of Maori rural idylls that aped those of the London photographic salons of the time; and portraits of sexually alluring maidens, cute Cupid-like naked children, and madonna-like Maori women carrying infants. Also popular were cards that, like some American postcards with Negro subjects during the same period, portrayed Maori as simple folk, unable to cope with the complexities of Western civilization.

All these pictures were more telling reflections of contemporary European attitudes than of Maori life. And while some Maori felt that the Europeans who took such photographs were themselves made to look extremely foolish, most believed such pictures demeaned Maori and Maori culture. Other Maori feared the commercialization of the images. If they were sold for money, they would lose their sacredness. Some of these attitudes toward photography persist today but are likely to be modified by the gradual emergence of Maori photographers who are sensitive to Maori views and fears about photography.

Most photographs of Maori in New Zealand, however, were taken by non-Maori. By that fact they become culturally loaded statements. The very presence of a camera operated by a European affected and altered the appearance, arrangements, and behavior of those being photographed. Inevitably the values and the beliefs of the photographers and the conventions of European art and photography affected the presentation of Maori in photographs. Some activities central to the day-to-day workings of Maori communal life are entirely absent because they did not fit notions of what was photogenic, because they would not represent Maori in contexts that a non-Maori audience would recognize, or because it would have been technically difficult to record them. In the early days of the medium it was necessary to photograph people standing absolutely still for long exposures, and outdoor pictures were always easier to take than indoor ones; consequently there are few interiors among the older prints.

These factors often combined to make historical photographs as concealing as they are revealing. They show selected public moments in Maori lives as arranged by the photographer. There is a plethora of nineteenth-century pictures of Maori standing outside their dwellings, often in their most formal clothing. Sometimes the prints include odds and ends that hint at the technology of the subjects' lives—kettles, cooking fires, blankets—and sometimes domestic animals and toys. To learn about the more intimate aspects of Maori lives, however, how much one would like to see *inside* their dwellings, and to see *them* inside—preparing food, eating, drinking, talking, sleeping, waking. And how much one welcomes the few photographs in which people seem alive rather than statuesque. The greatest cause for regret, perhaps, is that in the earlier years there were no Maori photographers who might have taken such pictures unobtrusively. □

Portraits of alluring maidens with such titles as A Maori Belle, *right, were the most popular category in the postcard trade. Commercial photographers at the turn of the century kept a wide range of these pictures on hand.*

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We keep raisi

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*Based on 1984 calendar year *Ward's Automotive Reports* and EPA Interior Volume Index for subcompacts.

HONDA

The Accord 4-Door Sedans

To El Chichón and Back

On an expedition to southern Mexico, scientists sift through the ashes of a deadly volcanic eruption

by Haraldur Sigurdsson and David Gardella

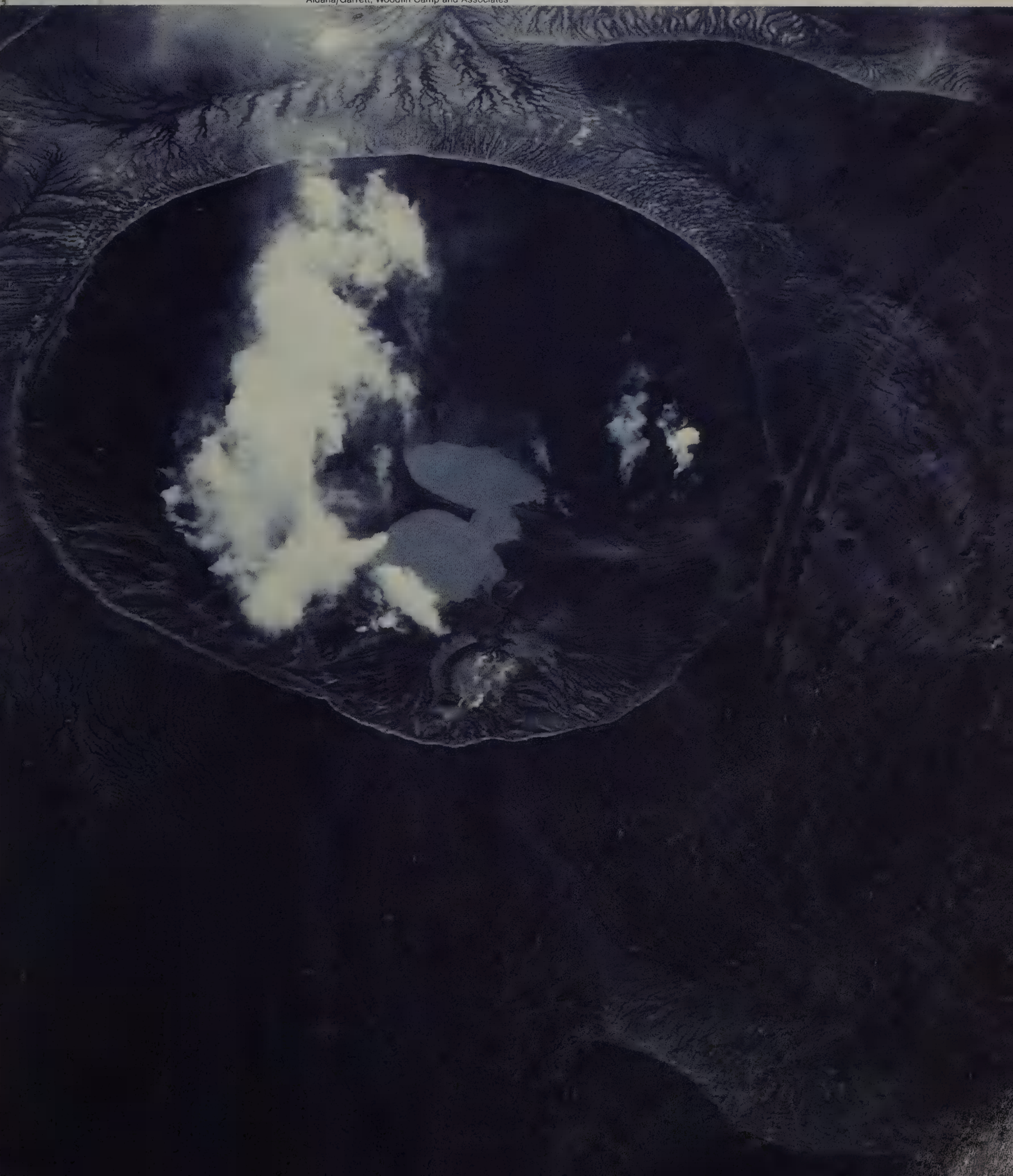
A little more than three years ago, El Chichón was a harmless-looking mountain in southern Mexico, covered with tropical forest. As a volcano it was obscure; certainly no one considered El Chichón a hazard. But early in March 1982, ominous readings began to appear on seismic instruments. The earth's vibrations were not strong enough to be felt, but late in the month they increased sharply, and on March 28 an explosive eruption broke out. Pumice and ash rained down on the surrounding towns and villages, caving in roofs as far away as Pichucalco, a distance of twenty-five miles.

Injury was light after this first eruption but the local Zoque Indian population became agitated. Churches were packed, and town officials blamed the alcohol-induced, sinful ways of the people for bringing down God's vengeance. Over the next few days, as small explosions were observed by eyewitnesses, recorded by seismic stations, and captured on satellite images of the region, scientists from the National University of Mexico began studying the newly active volcano. While researchers sought to assess the extent of further hazard, the Mexican army was mobilized to supervise evacuation and control access to the danger zone. The evacuation was slowly getting under way when army personnel and civilians alike were surprised by a second major eruption on the night of April 3. This time the force of the eruption was devastating, sweeping down the forest up to five miles from the crater and destroying nine villages. Approximately 2,000 people were killed.

The following day, April 4, saw the longest and final eruption, but by then many of the local inhabitants were dead. Thousands of head of cattle and all other forms of life in the area had also been exterminated. A huge cloud from the eruption spread rapidly westward at an altitude of sixteen miles and encircled the globe in twenty-one days. Direct sampling of this stratospheric layer by aircraft and balloons, as well as satellite studies, indicated a very high content of sulfur, which in combination with atmospheric water vapor formed a sulfuric acid aerosol. No other volcano had made such an impact on

An aerial view of El Chichón, taken several months after the April 1982 eruption, shows the sharp-rimmed crater from the southwest. Partly obscured by volcanic deposits, the irregular outline of a prehistoric crater, created by a large eruption about A.D. 1400, surrounds the new crater.

Aldana/Garrett; Woodfin Camp and Associates



the earth's stratosphere in the past twenty years, and several scientists predicted that the consequence would be a cooling trend at the earth's surface—a reverse greenhouse effect.

In June, shortly after the 1982 eruptions, we mounted our first expedition to El Chichón, which is located in the Mexican state of Chiapas. Seismic activity had ceased, but entry into the blast zone around the volcano was still highly restricted. Our interest was twofold: to determine the volcanic processes that had caused local destruction, and to study the geochemistry and mineralogy of the magma (molten rock) that had produced the sulfur-rich stratospheric aerosol veil. When we arrived, we found the area nearest the volcano still impassable. Some deposits of volcanic material were too hot to walk on, and the steady flow of volcanic gases from them made conditions almost unbearable.

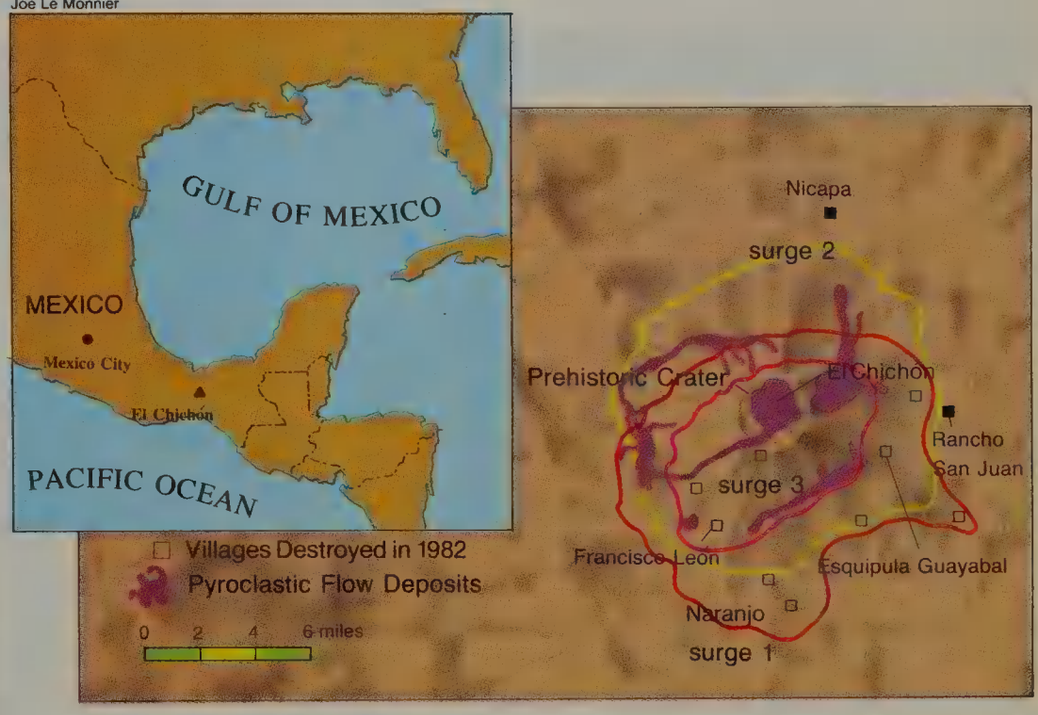
For the most part we were forced to limit our survey to the outlying ashfall, but we did learn one important thing from our closer observations: among the events that caused the devastation were pyroclastic surges and flows. A pyroclastic surge is a highly turbulent, hurricane-like avalanche of hot volcanic ash and pumice mixed with air and volcanic gases. Surges are often accompanied by pyroclastic flows, which are denser mixtures of hot ash and pumice that flow along valleys and riverbeds. We were eager to examine these violent processes, partly because they are believed to have figured prominently in the eruption of Vesuvius in A.D. 79. Our preliminary studies showed that within a five-mile radius of El Chichón, hot surge clouds, at temperatures of up to 800 degrees Fahrenheit, had blasted along the earth's surface with the force of a nuclear explosion. Fragments of rock, volcanic ash, and pumice were swept along at sixty miles per hour. Our interest aroused by these observations, we decided to let the area cool off for a while and planned a second expedition in January 1983.

On our return to southern Mexico, a Cessna airplane made three trips to take us and the other participating geologists (Steven Carey, Richard Fisher, and Juan-

Chris Johns; Seattle Times, Black Star

Left: El Chichón spews its sulfur-rich ash. The final and longest eruption was on April 4, when the plume reached stratospheric heights. Below: Nine villages were destroyed on the night of April 3 by a hurricane-like avalanche of hot ash and volcanic gases, known as a pyroclastic surge (Surge 1 on the map). This and a second surge were part of El Chichón's most violent eruption. The blasts were accompanied by outpourings of denser materials, called pyroclastic flows. The eruption on the following day included a third, smaller surge.

Joe Le Monnier



Manuel Espindola), along with our supplies, from the village of Pichucalco to the periphery of the sixty-square-mile area devastated nine months before. As we flew the twenty miles westward toward the volcano, we saw a knife-sharp boundary between the tropical forest and the barren, gray, ash-covered blast zone. There, about five miles from the crater, was the deserted ranch—El Rancho San Juan—that would become our base for five weeks.

The nearest inhabited village was Chapultenango, three miles to our east. Just outside this village, on the winding mountain footpath leading to our ranch, was a sign marking the restricted zone: *Peligro Volcán* (Danger Volcano). Westward from the ranch toward the volcano, the land was covered with bone-colored volcanic ash; it was devoid of all life except for the droning of insects. But in the opposite direction, the hills and mountains were resplendent with banana plants and other lush green foliage, and the sounds of birds and croaking frogs filled the air.

We spent the next day shoveling ash out of the ranch house, the headquarters from which we would launch daily forays to the volcano. The once beautiful green expanse of Rancho San Juan was now under twelve to sixteen inches of pumice and ash. Next to the ranch house were two battered Cessnas, which looked as if they had been riddled by machine gun fire. Their fuselages and wings had been perforated by falling stone projectiles during the first eruption, on March 28. Near the planes were the remains of a truck, facing away from the volcano. The paint on the front was unscarred, but the taillights were melted and the tires were burst by the heat of a pyroclastic surge. The surge had come to a halt only seventy feet from the ranch on April 3, killing many cattle.

Three days after our arrival, we set out on our first climb to the rim of El Chichón's new crater, which is nestled within a larger, prehistoric crater. After an hour's hike along a sulfurous stream, we reached the foothills of the volcano. Crossing a barren plain of pyroclastic flows, dotted with fumaroles venting hot steam, we ascended through steep and recently eroded canyons to the outer crater rim. We then confronted a wide moat, crisscrossed by a network of steep, narrow canyons. After tackling these badlands, we approached the new crater rim, the roar of fumaroles sounding ever louder. Finally, we scrambled up to the sharp rim and peered into the crater. About six hundred feet below was a hot lake of bright lime green, with sulfurous bands decorat-

Ash from El Chichón's April 4 eruption darkens the late afternoon sky in San Cristóbal de las Casas, eighty miles southeast of the volcano. Residents seeking to stock up on goods are admitted one at a time to a local supermarket.

Aldana/Garrett; Woodfin Camp and Associates

ing its edges. From the floor and walls of the half-mile-wide crater, hundreds of fumaroles spouted steam, fumes, and noxious volcanic gases. We began our mapping at the crater rim.

Our fieldwork involved identifying the volcanic deposits left by each eruption, mapping out their distribution, and measuring their thickness at different locations on the landscape. We also collected samples of the deposits for laboratory study of particle size and geochemistry. Basically, there were three kinds of deposits. The most widespread consisted of ash and pumice that had settled as fallout from the air (ash and pumice are distinguished simply by particle size—ash is the finer material). From the characteristics and distribution of particles in such deposits, we can learn various things about an eruption, such as its force and duration, the height of the column, and the wind conditions that prevailed when it occurred. In addition to the fallout layers there were debris flows fifteen to thirty feet thick, consisting of jumbled blocks and rock fragments of the old volcanic structure, and deposits that we identified as coming from pyroclastic surges and flows. There were no lava flows, which result from the extrusion of magma in a liquid state. Lava is formed only when the magma does not contain high concentrations of volatile compounds, such as water. At El Chichón, all the eruptions had been violent.

After a week's stay at the ranch we had completed geologic mapping of the deposits on the east side of the volcano, and it was time to move camp. Our next goal was the village of Francisco León on the south flank of the volcano. A geologist and a group of soldiers, along with a number of Indian villagers, had lost their lives there on April 3 in the blast of a hot surge cloud.

We arose early in the morning and made final preparations to leave Rancho San Juan for a five-day excursion through the forbidding blast zone. Two Indians from Chapultenango arrived leading four scrawny mules, and soon our mule train was under way. Since there were no trails, we picked our own route along valleys and gullies. After about an hour's trek, we reached a hill designated on the topographic maps as the site of the village of Esquipula Guayabal, about two and one-half miles southeast of the volcano. It was hard to imagine that under those barren gray dunes a village had thrived nine months before. Finally we found tangible evidence—two bent steel posts protruded from the ash, the supports for the nets in the village school basketball court. No other trace of the village showed above the three-foot-thick blanket of surge deposits.

From the Guayabal hill we looked ten miles down a long, bleak river valley toward Francisco León. Volcanic deposits had altered the valley topography, influencing the river's flow. Our passage along the narrow riverbanks was difficult, and often the easiest path was the river itself. Finally, we rounded a bend in the river and saw the broken stone walls of a church, precariously undercut by the rerouted river. These thick walls were the only village structures still standing. As we crossed through the leveled settlement,

llagers in Nicapa, north of the volcano, escaped the reach of the pyroclastic surges, t ashfall caved in rooftops. The village church and central square are at the top of e aerial photograph.

ana/Garrett; Woodfin Camp and Associates

e spotted traces of domestic life—pans, gs, a rusted machete, and a pair of scis-rs sticking out of the ash. We made our amp at a respectful distance from the dden remains of those who had been as-nyxiated by the surge cloud.

To the south was the green rain forest, hile the blast zone spread north to the olcano, four miles away. The blast zone as barren except for a few clumps of rass and some insects, especially dragon-es and butterflies. Fortunately, mosqui-es were virtually absent, perhaps be-ause the streams and ponds were acid-ed by sulfur that had leached out of the volcanic ash. All that remained of trees were scorched, broken stumps, but large-leafed elephant ear plants and tall grasses were making a comeback as close as two and one-half miles from the crater. Nature was less bleak at the edge of the blast zone, where vines and other greenery were creeping out of the forest. Here we spotted two killdeers, as well as small fish in the streams, and frogs and lizards appeared at our swimming hole. A few egrets and herons lived off the other wildlife. An ominous presence was a hungry pack of dogs that roamed the hills around El Chichón in search of food.

Every day we left our camp near the desolate ruins of Francisco León and mounted expeditions up the flanks of the volcano. After one week we were nearly ready to return to Rancho San Juan, but one task remained: a survey of the destroyed town of Naranjo, about five miles from the volcano and at the very edge of the blast zone. A study of the site would give us valuable information on the effects at the farthest end of the surge.

Naranjo is situated on a pedestal-like plateau, with a splendid view of the volcano in the distance. As we hiked onto the plateau, the town suddenly came into view. Many masonry structures were still standing, including the church, but the surge cloud had stripped other buildings of their roofs, thatched siding, and corrugated iron. All that was left of them were the carbonized wood corner posts, bent slightly away from the source of the blast. Cinder block buildings were damaged, generally with the walls broadside to the volcano caved in completely. The level of destruction surprised us, since the deposit from the surge was only about one to two inches thick on the ground. As we wandered through the eerie ghost town, which once included a modern hospital, we came upon the skeletons of several of its inhabitants, inexplicably scattered about on the surface of the volcanic ash. These bones, we discovered, originated from trenches dug in the ruins of several of the shacks and houses in the town. Looters had explored Naranjo before us and treated with utter contempt the remains of any victims they encountered. We found ourselves faced with the depressing task of gathering up the bones and burying them near the ruins of the church.

In the course of our investigations of the new volcanic deposits, we found evidence of the volcano's earlier history. The oldest deposits have been dated by the potassium-argon method to about 200,000 years ago, making El Chichón relatively young as volcanoes go. Four additional ancient episodes of activity could be discerned. One remains undated; the others have been dated by the carbon-14 method to roughly A.D. 400, 850, and 1400. This last eruption, which was an order of mag-

Because El Chichón's first eruption spurred a voluntary evacuation, many villagers living near the volcano survived. But the most violent eruption took about 2,000 lives.

Chris Johns: Seattle Times, Black Star

nitude greater than El Chichón's eruption in 1982, created the large prehistoric crater that surrounds the new crater. Before leaving southern Mexico, we also sampled distant ashfall from El Chichón. This took us to the Yucatan and Palenque, the location of spectacular temples of the vanished Maya culture.

Our study of the volcanic deposits in the ruins of Naranjo, Francisco León, and elsewhere around the volcano provided us with evidence to reconstruct the series of eruptions of El Chichón in 1982. All three of the major events—the first eruption of March 28 and the last two, on the night of April 3 and the morning of April 4—had left tangible evidence. The last of the intervening minor explosions, which occurred on the morning of April 3, also left a trace, a minor fallout layer that included small mud balls known as accretionary lapilli. These are evidence of an explosion caused by ground water coming into contact with magma.

One of our most important observations was that the particles in the next-to-uppermost fallout layer were the coarsest; this indicated an especially energetic eruption with high output per unit of time. This layer was sandwiched between two pyro-

clastic surge deposits. Two pyroclastic flows, each six to twenty feet thick, as well as the debris flows, formed adjacent layers. The association of all these deposits with the fallout from this one eruption gave further testimony to its violence. A third, smaller surge deposit rested on top of the uppermost fallout deposit.

Using this kind of field evidence, in conjunction with what was known from eye-

Naranjo, about five miles south of El Chichón, was destroyed on the night of April 3 by the first pyroclastic surge. Although the town was at the edge of the blast zone, charred corner posts, bent away from the volcano, are all that remain of many buildings.

Aldana/Garrett; Woodfin Camp and Associates

witness accounts, seismic recordings, and observations from satellite images, we reconstructed the following scenario. The first eruption, on March 28, was what is called a Plinian eruption—a steady, high, fountainlike discharge of pumice and ash. In a Plinian eruption, the volcano ejects a sustained jet of fragmented magma; this jet draws in and mixes with atmospheric air, which is heated and expands, acting to lift the column in a convecting plume. El Chichón's first eruption behaved in this way, sending up an eruption column at least eleven miles high. The fallout of volcanic ash and pumice was deposited in a thin layer over southern Mexico and had little effect except locally, where it was thick enough to cause roofs to collapse and (fortunately) to spur a voluntary evacuation of many residents.

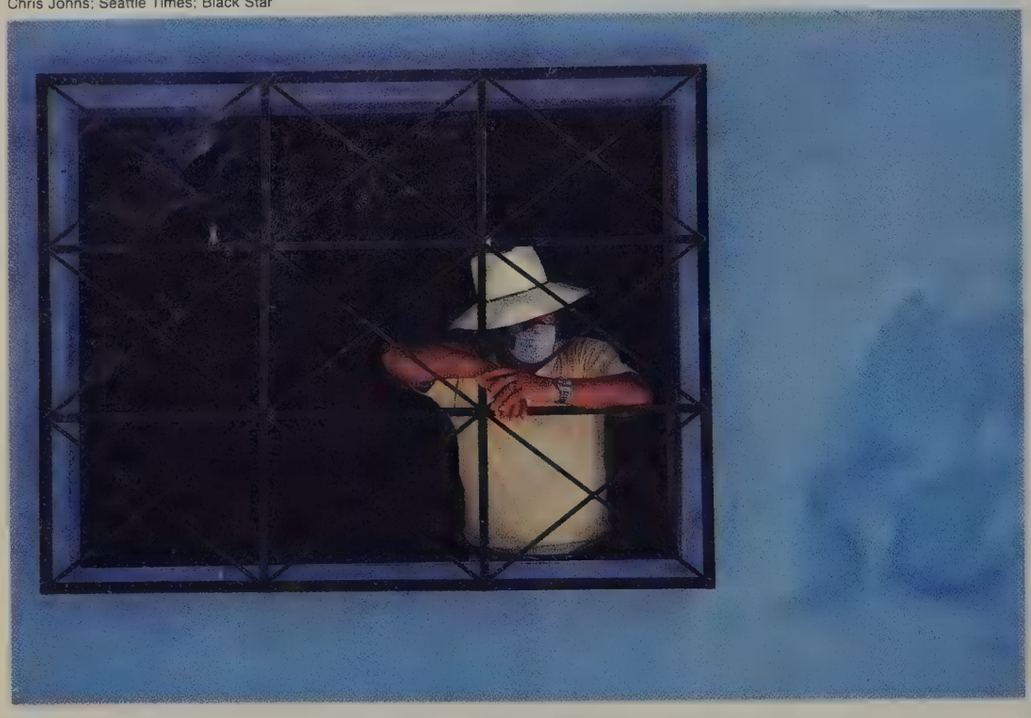
The first eruption punched a hole through the old volcanic dome at the summit of El Chichón. Over the next several days, ground water came into contact with the hot magma (about 1600 degrees Fahrenheit), causing explosions known as phraetic eruptions. The weak explosion on the morning of April 3, which left minor ashfall, was one such explosion.

The most violent eruption, on the evening of April 3, led to total destruction of the domelike summit of the volcano. This complex event proceeded in three stages. At first, the eruption column did not assume Plinian form; convective currents failed to lift the eruption plume. This may happen for various reasons, but in this case it was probably because the crater had been excessively enlarged or because the high rate of eruption prevented sufficient intermixing of air. Instead, there was a pyroclastic surge and flow, as the burden of volcanic material avalanched down the flanks of the volcano. This was the first devastating event during the series of eruptions and led to the destruction of the nine villages around El Chichón and the blowdown of the forests. Subsequently, the column gained buoyancy, and the eruption plume rose to stratospheric heights, with fallout of ash and pumice producing a thin deposit on top of the first surge layer. Within hours, the eruption column collapsed again, producing a second pyroclastic surge and flow similar to the first. This time, however, the surge spread over a lifeless, barren volcanic surface, except to the north, where it extended several miles beyond the edge of the first surge zone, stopping short of the town of Nicapa. Repeated collapses of an eruption column similar to this are believed to have been responsible for much of the destruction of Pompeii and Hercu-

Aldana/Garrett; Woodfin Camp and Associates

Below: Local residents had to cope with thick deposits of volcanic ash. Scientists are still debating what worldwide climatic effects may result from ash and volcanic gases that El Chichón lofted into the stratosphere. Opposite: Ashfall dusts the Temple of the Inscriptions at Palenque, Maya ruins that stand some one hundred miles to the east of the volcano.

Chris Johns; Seattle Times; Black Star



laneum during the eruption of Vesuvius.

The final explosive eruption was early the next morning, April 4. Although less energetic than the one that preceded it, this event lasted the longest and produced a column that may have extended to a height of sixteen miles. The eruption column was sustained and produced fallout of ash and pumice in large quantities until its final stages, when it collapsed, generating a small pyroclastic surge.

The sulfuric acid veil El Chichón created in the stratosphere, especially with this last eruption, received worldwide attention. When we returned to our laboratory at the University of Rhode Island, we began analysis of our samples of pumice and ash in an effort to explain the origin of the sulfur. We expected to find that the magma simply had a very high sulfur content, but much to our surprise, it contained only modest amounts of dissolved sulfur. Instead it contained anhydrite, a sulfur-rich mineral that is exceedingly rare in volcanic rocks. Apparently the breakdown of this mineral during the eruptions resulted in the massive release of sulfur gases to the atmosphere.

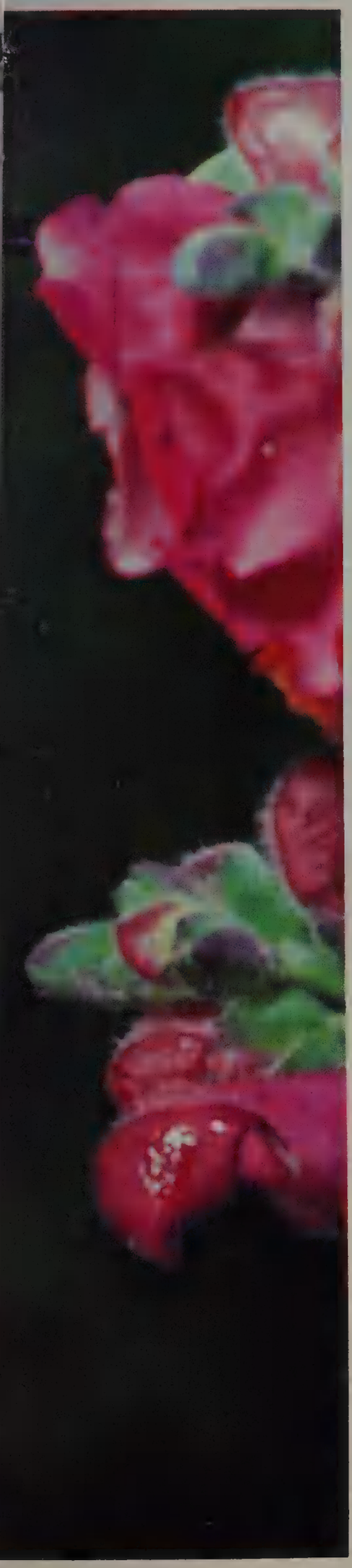
Fortuitously, El Chichón is close to some oil wells, and bore holes have yielded information about the geologic strata down to a depth of about two and one-half miles. At that depth there is a layer of evaporites, sediments left when seawater evaporated some one hundred million years ago. The sediments include, in addition to ordinary salt, a considerable amount of anhydrite. Although other explanations are possible, the volcanic magma most likely stewed in a reservoir enclosed in part by this sedimentary layer, and thus became saturated with sulfur.

In all, about ten million tons of sulfuric acid aerosol were injected into the stratosphere, forming a layer thirteen to sixteen miles above the earth. Since this layer backscatters incoming solar radiation and absorbs infrared radiation, many scientists predicted that the stratosphere would warm up and that this heat would be lost to us down here on the earth's surface. No volcano had injected such large quantities of volcanic aerosol since the Agung eruption in Bali, Indonesia, in 1963. During the year following that event, the earth's surface cooled about one degree Fahrenheit throughout the entire Northern Hemisphere.

Sufficient time has now elapsed to evaluate the possible atmospheric effects of El Chichón. In April 1982, almost immediately after the eruption, the earth's stratosphere at the level of the El Chichón aerosol layer became up to nine degrees Fahrenheit warmer. This strong effect, however, was later shown to have been partly due to a periodic change in stratospheric temperature, which happened to coincide with the eruption. Actual stratospheric warming caused by the eruption was estimated at no more than five degrees Fahrenheit. Did this warming result in noticeable heat loss at our planet's surface? Calculations showed that this should have been the case, but no surface temperature change was observed in the tropics. In north temperate latitudes, temperatures actually increased substantially—almost five degrees Fahrenheit above average—and global surface warming occurred immediately after the eruption.

The explanation for this paradox came when scientists realized that an intensification of the warm equatorial Pacific ocean current had coincided exactly with the El Chichón eruption, and its effect had more than canceled out the predicted surface cooling. This warming in the eastern Pacific, which occurs at rather irregular intervals, is called El Niño because of its association with the Christmas season. Its causes are mysterious, but it does affect surface temperatures in the tropics. Compared to previous events, the sea-surface temperature warming in the spring of 1982 has been called the "El Niño of the century." Scientists are still debating whether the veil of volcanic dust that El Chichón spread over the equatorial Pacific induced this strong El Niño.

Recent studies show that in addition to sulfurous material, the eruptions in 1982 also injected 40,000 tons of hydrogen chloride into the stratosphere, increasing the presence of that gas by 40 percent. This development could be of some concern because chlorine gases break down the ozone layer, the earth's principal shield against harmful radiation from the cosmos. Whatever its long-term effects may prove to be, however, El Chichón reminds us of the intrinsic differences in geochemistry among individual volcanoes. Although comparable in terms of total erupted mass and magnitude, El Chichón released about two hundred times more sulfur to the earth's atmosphere than the celebrated 1980 eruption of Mount St. Helens. □



A male Rivoli's hummingbird
Bob and Clara Calhoun; Bruce Coleman, Inc.

Stowaways on the Hummingbird Express

Nectar-sipping mites that hitch rides on hummingbirds are very choosy about where to get off

by Robert K. Colwell

To our eyes, the red and orange flowers of hummingbird-pollinated plants stand out in the deep shade of the rain forest like rubies on green velvet. To hummingbirds—whose range of color vision is even greater than ours—the contrast must be just as striking. But the rich world of odors is closed to hummingbirds, and our own poor olfactory equipment is little better.

The perennial human daydream to fly like a bird surely has its roots, in part, in the similarity of our sensory worlds. Who would not welcome the chance to be a tropical hummingbird for a day, given proper training? The exhilaration of fast and agile flight, the high-calorie diet, the beauty of the forest—all this we can envy and imagine.

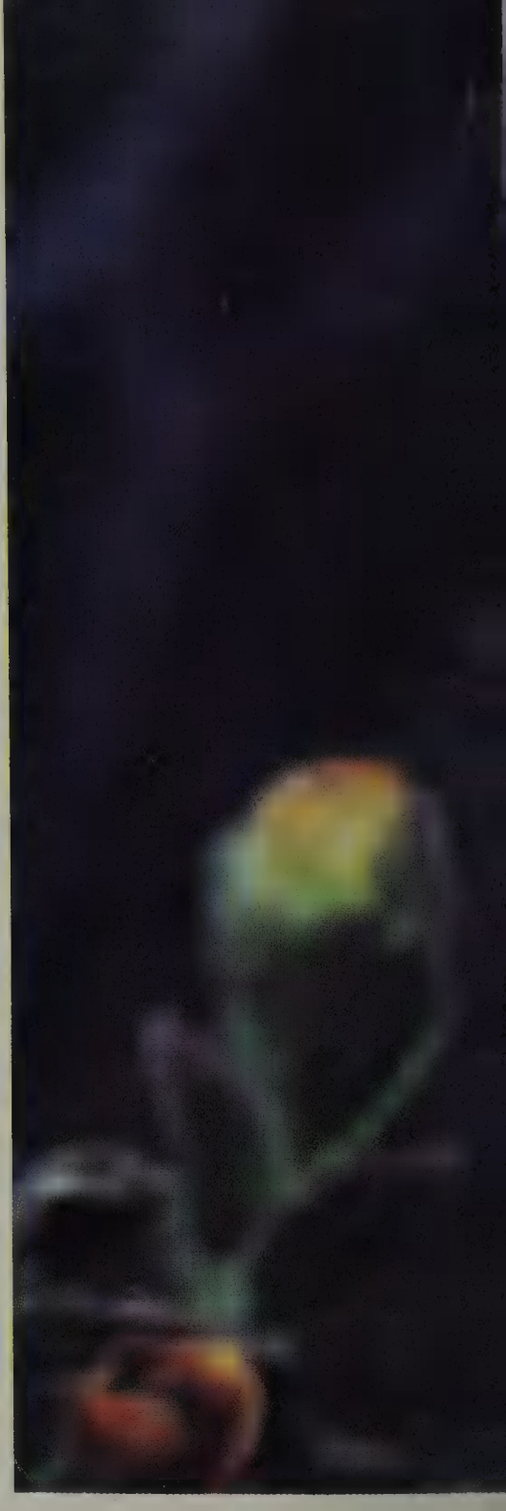
But now enter the same world on a different scale. Imagine yourself a mite just twice the size of the period at the end of this sentence. You are having a breakfast of nectar and pollen with your family and neighbors inside the orange-red, inch-long flower of a *Hamelia* plant at the edge of a rain forest clearing. You have no eyes and need none, because your four pairs of legs and your body are equipped with precisely arranged, minute hairs, called setae, that provide exact information about your special world. When you meet another mite in your flower, a quick touch with your foreleg tells you its sex and age, and the rate of encounter tells you how many other mites share your flower. You can even "smell" with some very special setae on the tips of your forelegs. Although neither hummingbirds nor humans can smell your flower, it has a distinct and very important fragrance for you. It smells like home, and home means safety, your own kind, mates, and food.

Suddenly you sense the vibrant approach of a hummingbird outside the flower. A half second later a bill sixty times the length of your body is thrust deep into your home and you must dodge the rapidly licking tongue that is draining your larder. In the one to five seconds before the hummingbird leaves for the next flower, you must make a decision that will affect the rest of your life. What are the future prospects for food, mates, and the welfare of your offspring on this branch of this *Hamelia* plant, compared with the chance that a risky journey will turn up better prospects elsewhere?

If you decide to leave, you dash up the bill of the visiting hummingbird and run into its nostril, and the odyssey begins. On board, inside the bird's nasal cavity, the accommodations are primitive. There is nothing to eat or drink. The place is crawling not only with your own kind but also with aliens of other species of hummingbird flower mites, hitching rides to their own promised land. You will know them by their smell, perhaps, and by the strange arrangement of their setae—long where yours are short, straight where yours are so beautifully curved.

But the ventilation on this feathered freighter is absolutely first-class. A hundred times every minute or so, a hurricane of fresh air rushes in. More than just a source of oxygen, the hummingbird's respiration acts as an odor pump, constantly updating information on the outside world. What you await is that familiar smell—the odor of your own host plant,

David S. Dobkin



Mites that live only in hummingbird-pollinated flowers travel to distant blossoms by climbing on a bird's bill and taking shelter in its nostrils. Below: A Rhinoseius colwelli *mite crouches within a bird's nostril while another stands by. Right: This California species of Indian paintbrush supports a contingent of* R. epoecus *mites, a species discovered recently.*

Shahid Naeem

Hamelia. The hummingbird may visit the flowers of half a dozen other plant species, and the aliens on board may come and go, but you wait until the scent of *Hamelia* tells you the bird has its bill in the flower. You have one to five seconds to disembark. With luck, if you are a male, you will find females in need of a mate in your new home; if you are a mated female, you will find that a nearly empty flower, with a male or two present to replenish your supply of sperm, would be an ideal place to start your own dynasty.

A primary research journal would probably scorn the shamelessly dramatic account you have just read. Yet every good naturalist learns to "see into the life of things," as Darwin put it, in part by identifying with the organisms studied. Even botanists do it. The danger, of course (and the reason for the taboo on exposing such musings in scientific print), is that we may unwittingly and inappropriately impose human capabilities, limitations, or even values on nonhuman organisms. For example, a mite certainly makes a "decision" in a very different sense than we do.

Fortunately, our understanding of the biology of hummingbird flower mites rests on more than daydreams. I first stumbled on the existence of these mites and guessed their relationship with flowers and hummingbirds in 1969 in the Costa Rican highlands. In succeeding years, the project that began at that time broadened geographically and scientifically as my colleagues and I developed new techniques of study and a deeper understanding of the daily lives of hummingbird flower mites. Peter Feinsinger, of the University of Florida, an authority on tropical hummingbirds, has collaborated generously, and my doctoral students, David Dobkin, Amy Heyneman, and Shahid Naeem, have poked their own noses into the flowers of *Hamelia* and other hummingbird plants in intensive field research in California, Mexico, Costa Rica, and Trinidad. Barry OConnor, of the University of Michigan, has scientifically described and named many of the new mite species we have found.

Hummingbird flower mites are freeloaders. As far as we can tell, they do nothing of note for their host plants or for hummingbirds. Yet their survival depends on the interdependence of birds and flowers, which are mutually linked by the exchange of nectar for pollination service. A closer look at hummingbirds and plants reveals the way this network operates.

Within the limits of a very consistent body plan and behavioral repertoire, the more than three hundred species of hummingbirds present an astonishing diversity of body size, coloration, plumage, and bill shape and length. They are strictly a New World group, with outlying species found, at least during the breeding season, from Alaska to Tierra del Fuego. A few acres of tropical forest can contain a dozen or more abundant hummingbird species. The plant species that hummingbirds pollinate number in the thousands and represent dozens of plant families.

Hummingbird flower mites are found nearly everywhere there are hummingbirds. So far, we have recorded the mites from more than one hundred host plant species and from more than sixty hummingbird species, and these records represent only very spotty coverage of the range of hummingbirds. But even where the mites have been studied, not every species of hummingbird-visited plant supports them. Hummingbird-pollinated species in some plant families never have these mites (for example, the mallow, mint, and fuchsia families), and some nearly always do (tropical species in the lobelia, blueberry, and many other families).

Hummingbird flower mites belong to two closely related groups, the genus *Rhinoseius* and a large lineage within the genus *Proctolaelaps*. The dozens of species we have studied so far are nearly all new to science; one or two hundred species are perhaps still undiscovered. As far as we know, only one species resides seasonally in the United States. This *Rhinoseius* mite summers along the California coast in the flowers of Indian paintbrush (*Castilleja*). It spends the winter in the mountains of west-central Mexico with California migrant hummingbirds and in recent times, in the flowers of African aloes in central California gardens. Shahid Naeem and I have named the species *epoecus*, from the Greek meaning "a sojourner from a foreign land." The greatest diversity of hummingbird flower mites is in lowland tropical forests, where a dozen or more species often share an acre.

Hummingbird flower mites are very discriminating in regard to their host plants. In the lowland tropics, each species

ypically occupies only a single host plant pecies, which blooms all year. By contrast, mite species at high elevations and igh latitudes, where flowering is more easonal and less reliable, usually have a hoice of two or more host species that hey often use sequentially. In most cases here is only one species of hummingbird lower mite per plant species, but in a few ases there are two—always a *Rhinoseius* pecies and a *Proctolaelaps* species, never wo species of the same mite genus.

Host plant species differ strikingly in easonal flowering pattern, the size and arangement of flowers, the amount of nectar each flower produces, and the longevty of each flower (half a day to more than week). These differences in host plant bilogy profoundly affect the mites.

Life begins for a hummingbird flower mite as an egg nearly one-fourth the volume of its mother's body. (Nonetheless, she can produce half a dozen eggs in a few hours.) Some species whose host plants have long-lived flowers lay their eggs right in the nectary of the flower, where they are bathed in nectar for a few days until they hatch. Mites that live on plants whose flowers open in the morning and drop later the same day lay their eggs among bracts or beneath leaves near the flowers. The eggs hatch into active six-legged larvae; this stage is quickly followed by two active eight-legged nymphal stages that precede adulthood. The mite goes from egg to breeding adult in about a week.

While it is easy to find mites by cutting open their host flowers, it is hard to watch them within the bloom unobtrusively. Fortunately, as long as they have their flowers, even on a cut branch in a vase of water, they seem not to notice being moved into the field laboratory for scrutiny. With a fiber-optic light, which produces intense light but very little heat, we can illuminate their miniature world for study with a dissecting microscope, apparently without disrupting them. Most of the behavior we observe in this way is repeated in glass capillary tubes with nectar.

The inside of a tubular flower is a fairly complicated place. Adult mites tend to congregate near the nectaries, in the base of the flower in most species, while the nymphs and larvae spend more time on the stamens and style. During all these stages the mites drink nectar, which contains proteins, fats, and amino acids, as well as sugars.

Proctolaelaps kirmsei adults avidly

Although imperceptible to humans and hummingbirds, the scent of a host plant, such as Hamelia patens, *below, prompts mites on a bird's bill to disembark. In field and laboratory, mites consistently recognize the odor of the host plant and prefer its nectar to equally nourishing substitutes.* Centropogon cornutus *produces exceptionally long-lived flowers, right. While other mites must lay their eggs on the leaves or bracts of their host plants, those that live on* Centropogon *lay eggs in the nectar, and the young hatch and mature within the blossom itself in a week's time.*

Robert K. Colwell

"process" pollen grains for a short period after entering a new flower of their host plant, *Hamelia patens*. The flowers of this plant open shortly after midnight (at least in Costa Rica), long before its pollinators become active at dawn. The mites rush in as soon as the flower opens. They immediately begin a frenzied attack on the pollen packed in the anther sacs, using a pair of short appendages to move one grain at a time over their mouthparts. We suspect that the mites are removing nutritious substances that coat the pollen grains. In terms of relative size, it would be as if you had before you a large bin of basketballs covered with peanut butter and honey, which you picked up one by one to lick.

When an individual flower has fully bloomed, the mites are able to leave it on foot to lurk about the same flower cluster until the next flower opens. Passage between clusters, however, seems usually to require the unwitting assistance of a hummingbird. In field experiments, uninhabited flower heads closed to mite foot traffic but exposed to hummingbirds are quickly populated by mites.

Hitching a ride on a hummingbird requires timing and agility. Taking the length of the mite as two-hundredths of an inch (some species are smaller), the bill length of the bird as about one and a quarter inches (some are longer), and allowing a generous five-second feeding visit by the bird, the mite must run as fast as a cheetah, for its size, to make it into the nostril before the bird moves on. (In other words, both hummingbird flower mites and cheetahs can run about twelve body lengths per second. We have actually clocked the mites at this speed in wind sprints around the lip of a test tube.)

"Deplaning" presents new difficulties. Before racing down the bill into a flower, the mites must first determine whether or not the flower is of their own host species. Our records for many thousands of mites show that no more than one in two hundred has disembarked in the wrong flower. Yet many hummingbirds visit several species of plants in an hour's time, and often each plant has its own species of hummingbird flower mite. How do they know when to get off?

By far the most likely source of information is odor. With the bird's bill in a flower, mites in the bird's nostrils could quickly determine the species of the flower and act accordingly, based on odors provided by the bird's rapid respiration.

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Our evidence is indirect but convincing. Given a choice of nectars in a T chamber, hummingbird flower mites choose nectar from their own host plant species. In Trinidad, for example, we offered the mite *Proctolaelaps kirmsii,* which lives in the flowers of *Hamelia patens,* a choice between nectar from uninhabited flowers of *Hamelia* and equally "virgin" nectar from flowers of *Centropogon cornutus,* the home of another mite. We put a drop of *Hamelia* nectar in the tip of a tiny glass capillary tube and a drop of *Centropogon* nectar in another. The open ends of the two tubes lead into an enclosed three-way "intersection" in a small block of acrylic. The third entrance to the intersection (the leg of the T) is another capillary tube with a mite from *Hamelia* in it. Twenty identical chambers were simultaneously set up. We kept track of the location of each mite in its chamber over a period of hours.

The mites in this experiment strongly preferred the nectar of their natural host plant—nearly all of them ended up in the tubes with *Hamelia* nectar, rather than in the tubes with "alien" *Centropogon* nectar. But when we put mites from *Centropogon* (another species, *Proctolaelaps glaucis*) in the same setup, they preferred *Centropogon* to *Hamelia* nectar. The mites are even more consistent in nature, where they are presented with one host plant odor at a time in a moving stream of air rather than two odors in still air.

Many species of hummingbird flower mites from Trinidad, Mexico, Costa Rica, and California have participated in our T-chamber experiments. A consistent pattern emerges. Each species prefers its own host nectar to the nectar of other species of mite plants. The mites also choose their own host nectar over sugar water of the same concentration and over nectar from miteless plants, that is, hummingbird-visited species that never support hummingbird flower mites. Amy Heyneman, who has analyzed dozens of nectars from both kinds of plants, has found biochemical differences between the two groups of nectars. Our field experiments, however, show that, within broad limits, the host nectar of one mite species is nutritionally acceptable to other mite species in the same habitat. We forced mites to live in newly opened, unoccupied host flowers of a plant normally inhabited by another mite species. A nylon mesh bag excluded hummingbirds and thereby prevented escape of the mites, many of which survived to reproduce successfully.

Why, then, are the mites so particular about the host plants they actually use? If every flower were densely populated with mites, competition among mite species for nectar might explain the adherence of each mite species to certain host plant species. However, the density of mites is quite low, relative to the nectar available, so competition between mite species is not a likely explanation for the very rigid plant–mite affiliation. Another possible explanation is that each mite species aggressively excludes "aliens" from its host plant. But most pairs of mite species get along quite amicably in laboratory tests. Moreover, certain pairs of species share the same host plant on a regular basis.

The explanation I favor for host allegiance is that hummingbird flower mites use host plants as a way of finding mates. Once a particular host plant species becomes the most popular jumping-off place for a given mite species, the mating success of mites that get off elsewhere will suffer, on average. Because in these species both males and females must mate many times to achieve their maximum reproductive potential, mites of either sex that disembark at the correct host plant will leave more descendants.

If I am right in thinking that plant affiliation evolved among hummingbird flower mites in large part through differences in

mating success, then host affiliation can be viewed as the product of sexual selection. Darwin first drew the important distinction between evolutionary changes based on inherited differences in survival rate and in the potential for reproduction, the process he called natural selection, and evolutionary changes based on differences in mating success in itself, a phenomenon he termed sexual selection.

Darwin believed that natural selection and sexual selection could, at times, conflict. Some physical and behavioral traits of animals are thought to have evolved largely through their role in courtship and mating, perhaps even at the cost of decreased survival. Well-known examples include the beautiful but cumbersome peacock's tail, the elaborate and seemingly arbitrary bowers constructed by male bowerbirds, and the magnificent songs of thrushes, which can attract predators as well as mates.

Just as more elaborate peacock tails presumably increased their owners' success in attracting peahens, strong allegiance to a particular host plant species boosted the mating success of hummingbird flower mites. Like other sexually selected characters, host affiliation involves a degree of arbitrariness and probably carries an element of risk as well. For a mite that has specialized on a single host species, even a brief flowering failure in the plant could mean the mite's extinction.

My co-workers and I suspect such extinctions must be rather common, on the scale of mere thousands of years. However, unless the flowering of all host species were to fail simultaneously from California to Chile and throughout the New World tropics—a most unlikely event—the future of hummingbird flower mites as a group seems assured. Their dynamic evolution all but guarantees that newly evolved species will eventually replace extinct ones, even in the same host plants. Some species even thrive harmlessly on the nectar of garden plants (including African aloes in California) along with the hummingbird visitors that delight the gardener. Despite the risks that they face daily, stowaway mites are well suited to life on the run. □

A long-tailed hermit hummingbird, bearing mites on its bill, samples the nectar of a scarlet passionflower. The mites will remain on the bird until it arrives at the "right" flower. By sharing an affinity for particular host plants, mites of the same species may expedite mate finding and improve their reproductive success.

Michael Fogden

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Questioning Survival

by Norman A. Chance

Imagine, if you can, a human settlement in which the majority of those who die before the age of nineteen do so by their own hand, a place where violence is so pervasive that the odds of dying a natural or accidental death are only about one in four. Imagine, in a society once noted for its indulgent devotion to its young, that in one year one-third of the children between five and fourteen were taken from their parents by the Children's Aid Society for reasons of physical and sexual abuse, severe neglect, or abandonment. These are but a few of the statistics cited by Anastasia Shkilnyk in her penetrating and sensitive analysis of the fate of Grassy Narrows, a Canadian Indian community that has been devastated by change. In *A Poison Stronger Than Love: The Destruction of an Ojibwa Community,* we learn that in this small village in northwest Ontario, beatings, murder, rape, incest, senseless vandalism, and other forms of social pathology have become the collective norm. It is a world turned upside down.

Why, the reader may ask, would the community of Grassy Narrows, once highly supportive of kin and spiritually attached to the land, self-destruct in such a manner? What disasters could be so all-encompassing as to reduce a competent, self-reliant people to such a condition? A poignant though less than satisfactory answer is found in the response of a resident villager: "I can't explain it to you, because I can't explain it to myself. The only thing I know is that alcohol is a stronger power than the love of children. It's a poison, and we are a broken people."

The author describes in graphic detail the prolonged and frequent bouts of spree drinking, the most visible element of widespread alcohol abuse throughout the village. As an urban and regional development specialist, she knows such eruptions are but manifestations of a much deeper malaise. Yet even her experience working in the slums of Santiago, Chile, and in war-torn Ismailia, Egypt, had not prepared her for what she describes as the "numbness of the human spirit" that typifies the residents of Grassy Narrows. And so she set out to find the underlying causes.

Insights were not long in coming. Shkilnyk soon learned that in the summer of 1963, the nearby Indian Affairs office had begun relocating the residents of Grassy Narrows from their old "reserve" on the English-Wabigoon River to a new site on a logging road. In the opinion of the government, the relocation would make it much easier to provide the residents with a school, medical care, improved housing, electricity, and other benefits of a modernized Canadian way of life.

A POISON STRONGER THAN LOVE: THE DESTRUCTION OF AN OJIBWA COMMUNITY, by Anastasia M. Shkilnyk. *Yale University Press, $30.00 (hardcover), $9.95 (paper); 275 pp., illus.*

However, relocation also separated the people from their ancestral lands. It disrupted their social organization—the clan-based extended family. It reduced their participation in the seasonal economy of the region, trapping for furs in the winter and guiding sport fishermen in the summer. And it weakened their almost symbiotic relationship with the animals and land—a hallmark of their way of life. Such an economic and cultural disjunction carries a penalty well known among

North American Indian groups suffering similar travails of poverty, loss of identity, and decreasing ability to shape their own future.

Originally, kinship was the major factor in how Ojibwa society had organized its labor, determined access to its resources, and defined rights and obligations involved in their distribution and consumption. The Ojibwa channeled their economic efforts through these kin-based relations, and any part-time involvement in a cash economy supplemented rather than replaced their own means of livelihood.

Following relocation, the kin-based way of life on the winter trapline all but disappeared. School-age children were required to attend the newly constructed reserve school. A government-built housing development, modeled after densely populated white suburban communities, provided new homes for a people used to more isolated living arrangements. Moose hunting, a common subsistence activity in the spaciousness of winter encampments, became all but impossible in the confines of a year-round village settlement. Gardening, another mainstay on the old reserve, was largely abandoned because of the poor quality of soil at the new location. Most former hunters and trappers became subordinate producers in enterprises such as commercial fishing. In times of unemployment, welfare payments provided by a government trying to integrate the Indian population into the Canadian mainstream further encouraged this new dependency.

Unfortunately, this vicious cycle of forced migration, economic dependency, loss of cultural identity, and breakdown in social networks is not uncommon in Indian

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In Grassy Narrows, two-thirds of the adults are heavy drinkers. Hiro Miyamatsu

communities. Yet the long and well-documented history of similar processes among other native North Americans suggests that such events, socially and psychologically devastating as they may be, do not adequately explain the extreme self-destruction at Grassy Narrows. In Shkilnyk's mind, a key factor was still missing.

A 1967–68 report by Norvald Fimreite, a Norwegian biologist at the University of Western Ontario, suggested that another crucial environmental factor had played a role at Grassy Narrows. Fimreite had studied the impact of industrial mercury on fish and birds in the area. His conclusion: the fish downstream from a nearby pulp and paper mill and chloralkali plant contained unacceptably high concentrations of methyl mercury. Further research demonstrated that fish taken downstream from all the chloralkali plants in Ontario contained body burdens of mercury that were more than forty times the allowable federal standard of 0.5 ppm (parts per million). As the magnitude of this environmental disaster became known, commercial fishing was banned in the area, tourist camps closed, and affected residents were warned not to eat the contaminated fish.

In response to a broadside of criticism, the pulp and paper industry claimed it had—as Shkilnyk succinctly phrases the argument—a "license to pollute" from the Ontario government. Since it had respected existing environmental regulations, the company maintained it could not be held exclusively liable for the disaster. Such proposals laid the basis for the industry's overall view that mercury poisoning was a societal responsibility and that any claims for damages would have to be settled by the courts.

For the people of Grassy Narrows, methyl mercury carried a bundle of messages. It meant the total loss of employment in the now-banned commercial fishing industry and a large reduction in guiding and tourism. It meant a severe decline in their subsistence food supply. It meant a new poison, in addition to alcohol, was entering their bodies—a fact continually highlighted by lurid newspaper accounts, detailed medical investigations, and written warnings by governmental health authorities that some members of the village had abnormally high (above 100 ppm) levels of mercury in their systems. And finally, as they found themselves being used as pawns by the major players, government and industry, in what Shkilnyk refers to as the "politics of mercury," it served as a vivid reminder of their seeming powerlessness to influence the course of their own lives. As the residents described it, mercury was simply "the last nail in the coffin."

Today, 71 percent of Grassy Narrows residents are under twenty-four years of age. None have the skills that enabled their fathers to live in the bush. Unable to find employment in the wage economy, most young men and women are entirely dependent on government grants. Their sense of hopelessness, and that of their elders, is clearly reflected in the carefully selected montage of fine photographs taken for the volume by Hiro Miyamatsu.

Another, quite different, factor exacerbates this sense of despair. For the people of Grassy Narrows, as for many native North Americans, land is not just a part of nature; it is also endowed with spirits that transcend nature. Land is, in essence, a gift to be held "in trust" for future generations. If that trust is broken, if the land is damaged, assistance is unlikely to be forthcoming. After all, poisoned land, like poisoned people, becomes angry. This is in contrast to our Western economic system, in which property ownership is considered an inalienable right and land is bought and sold like any other commodity. Our North American marketplace has little interest in sharing, spirits, or communal stewardship. Instead, our values stress that problems can be solved through technology, that progress is intimately connected with the need for constant growth, that restrictions placed on competition should be minimal, and that the individual's initiative to excel—even at the expense of others—is to be admired and emulated.

The residents of Grassy Narrows have had to withstand a mounting series of attacks on their sustenance, their culture, and finally their bodies—an assault seemingly without end or solution. They are unable to shape their lives in a manner consistent with their beliefs and find little constructive help from outside their community. Frustration and anger have taken over. Whether this anger is directed toward others or, as is more frequently the case, turned inward in keeping with traditional cultural patterning, it is not likely to dissipate as long as the conditions promoting it remain unchecked.

Is there a lesson for the rest of us? Anastasia Shkilnyk responds in the affirmative, suggesting that many of the pressures crippling the people of Grassy Narrows are similar to those impinging on us. What happened at Grassy Narrows, she concludes, "can serve as a warning that our own survival depends on restoring a sense of mutual responsibility for one another and ultimately for the fate of the earth. Love has to become a stronger power than the poisons of self-interest and powerlessness or else we will all perish."

While teaching at McGill University in the 1960s, Norman Chance directed the McGill-Cree Project, a long-term study of Indians in central Quebec. Now a professor of anthropology at the University of Connecticut, he is currently engaged in research on Alaska's North Slope.

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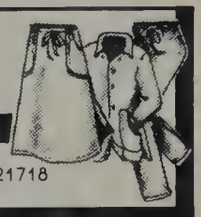

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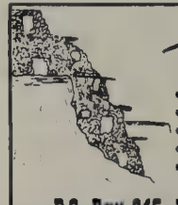

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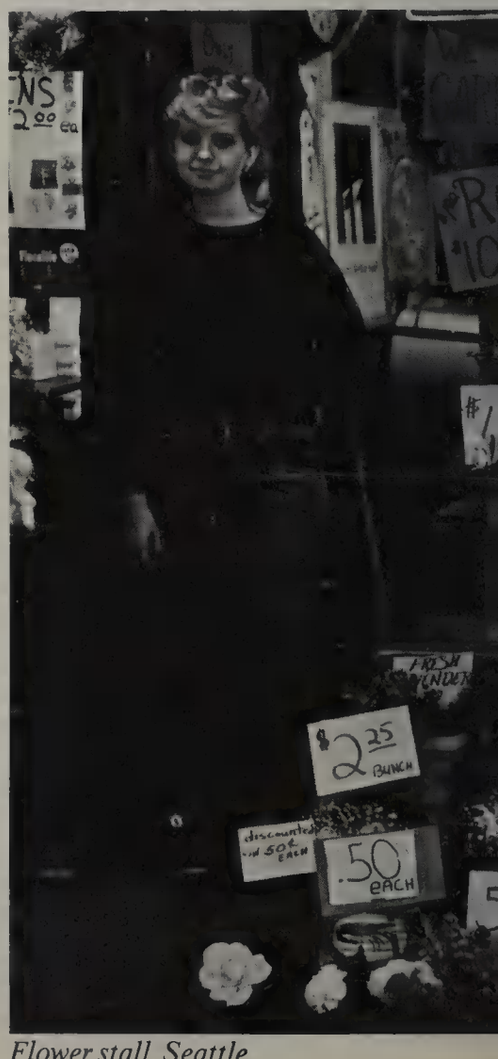

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Cold Spirits

In the U.S.S.R., there is a minicuisine of flavored vodkas that began as home-grown folk art

by Raymond Sokolov

Russia's favorite cocktail, according to my favorite Russian cookbook author, Anne Volokh, is the Polar Star. "Take ½ glass vodka," she explains in *The Art of Russian Cuisine,* "add another ½ glass of vodka, and stir thoroughly." This passion for pure, clear spirits may seem witless and pathetic, but it is actually the basis for a fascinating minicuisine of flavored vodkas that has survived all the disruptions of the past eighty years and still stands as a testimony to the innate sensitivity of Russian palates.

Today, cooks in the Soviet Union would find it impossible to prepare many of the 4,000 dishes described in Elena Molokhovets's *A Gift to Young Housewives,* a classic Russian cookbook written in the 1870s for middle- and upper-class women. No new editions of this book by the Russian Mrs. Beeton have come out in Russia since 1917, but secondhand copies of *A Gift to Young Housewives* cost the moon now in Moscow. And, says Mrs. Volokh, "readers pore over it as if it were a historical novel, marveling at the quality of a life long gone."

A selective annotated edition of the Molokhovets book is now being prepared by Joyce Toomre at Harvard University. She kindly let me look at a chapter of the manuscript, which is a painstaking, scholarly effort to make this crucial document of late imperial Russian bourgeois life available to American readers. But the recipes are so old-fashioned and reflect such a different way of life that most cooks will not find it easy to translate them to practical effect in a modern American kitchen.

This is exactly what Anne Volokh has done with some of the Molokhovets recipes. She herself had not cooked many of them until she left the U.S.S.R. and gained access to suitable raw materials in American markets. Volokh was the food writer for the Sunday edition of the Soviet newspaper *Izvestia* before she and her family emigrated to Los Angeles. Her cookbook was published in 1983, and it is an extraordinary achievement for several reasons. First, it is hugely informed and professional, with an encyclopedic array of recipes written with the clarity and authority that come from years of practice at a popular newspaper. Volokh has also taken the trouble to tell an American audience how Russians feel about their food and how they consume it. In other words, her book is strong on context and sociology. It is also literary, rich in gastronomic quotations from classic Russian authors.

These toothsome passages are not just there as gorgeous window dressing. Taken together, they form a mosaic of a lost world of Russian abundance and hospitality. Heading the chapter on *zakuski,* or hors d'oeuvres, for example, is this epigraph from Gogol's *Dead Souls:*

> "And now we shall send boredom packing," the host said. . . . "Why aren't they serving the snacks?" The door opened. Emilian and Antoshka appeared with the napkins, laid the table, and set down a tray with six decanters of various flavored vodkas. A necklet of plates displaying every kind of tempting savory soon surrounded the tray and decanters. The servants moved about smartly, bringing in covered casseroles which gave off a sizzling sound of melted butter. . . . After the snacks came the dinner.

Anyone interested in exploring what those snacks were or what was served in the dinner that followed could do no better than to read Volokh and cook her recipes. But lately I have been reading her for a more specific reason. During the past few months, I have been preoccupied with flavored vodkas for reasons that will become clear in a moment. And the Volokh volume is the most complete authority on the subject, even better than Molokhovets's book, which ignores vodka concoctions of the sort now popular in the Soviet Union.

The Molokhovets recipes for vodka involve cooking—vodka is heated with, say, fruit and sugar, and ends up verging toward such Western delicacies as brandied pears or blackberry cordial. The prepared vodkas I am concerned with are also traditional, but they are cold infusions of highly aromatic substances. They are always served ice cold, and their purpose is to isolate flavor, in its very essence, without the distraction of sweetness. The closest examples from other cultures that come to mind are the white alcohols distilled in France from a mash of pears or raspberries (or, less commonly, from plums, wild strawberries, and holly). But these luxurious "brandies" begin as fruit. The Russian flavored vodkas start as neutral spirits and are doctored with powerful flavoring elements that no one would normally eat separately.

In the U.S.S.R. today, according to Volokh, what was evidently a home-grown method of spicing up vodka has been industrialized. She mentions four brand names—Starka, Ierofeich, Petrovskaia and Okhotnichia—labels applied to vodkas infused with "anywhere from 3 to 4 flavors—sage, heather honey, angelica root, ginger root, anise, juniper berries, Crimean apple and pear leaves, mint, young shoots of mountain ash, nutmeg and nutmeg blooms, vanilla, cinnamon, cardamom, cloves and others." The commercial producers of these drinks mix an

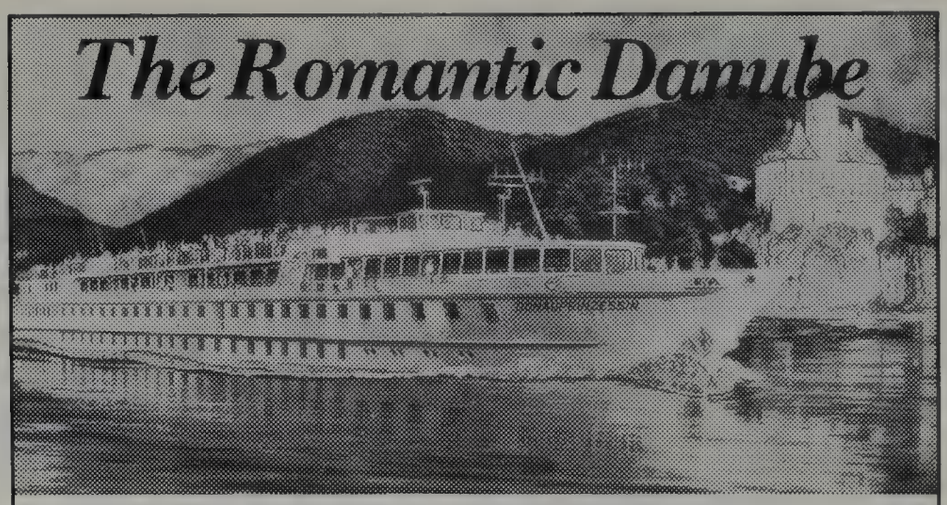
Matter of Taste

end them from a copious spice shelf, but ussians who flavor their own vodkas at ome tend to work with one flavoring ele- ent at a time.

The most famous example of this is the odka infused with an herb called buffalo rass, or *zubrovka.* Also well known are odkas in which caraway seed, citrus peel, ack pepper, or chilies have been macer- ed at room temperature for a week. Pep- er vodka, or *pertsovka,* a chili-inflamed, mber-colored eye-opener, is available ommercially in this country at large li- uor stores. But it is so easy to make that it hardly worth spending money on an im- orted product or wrestling with qualms bout trading with the enemy to acquire And if you try one of the following reci- es, you will probably be tempted to ex- eriment on variations that suit your own stes.

This must have been the spirit in which his whole genre of drinks was originally onceived—people puttering about at ome, dropping one thing or another into a ottle of hooch to make it taste better. nd yet it would be misleading to pass off avored vodkas as a sort of low-class folk rt. Volokh talks about the major-domo of he English Club in Moscow in the nine- enth century, an epicure called Shably- in, who supervised the creation of vodkas avored with birch and black currant uds.

The cult of these flavored vodkas has re- ently spread to the United States. My uru in this area is an American Slavicist, Martin Horwitz, whose lemon vodka was he inspiration for my own improvisations. s you drink one of these flavored vodkas, ou are swept away by the intensity of aste. And if you reflect about the phe- omenon, it will eventually occur to you



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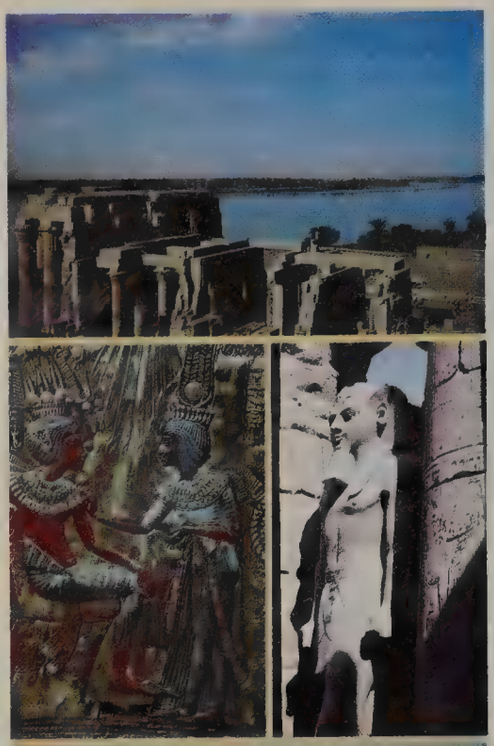

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that it is odd that extreme cold is an indispensable part of the experience.

The idea of serving flavored spirits cold is well established and, of course, is not exclusively a Russian notion. The Swedish version of flavored vodka, caraway-infused aquavit, is customarily served right from the freezer and is sometimes presented with the bottle frozen in a block of ice. This is not done merely for show. I have repeatedly experimented with side-by-side tastings of ice-cold and room-temperature samples of the same flavored alcohol and found the cold drinks exhilaratingly focused in aroma and the tepid ones insipid.

Normally, cold reduces the intensity of flavors, while heat increases them. Think of the smells that spread through a house from an active kitchen, and then think of the same food, pale and inert, as it comes from the refrigerator the next day. And yet, the most intense distillations of flavor I know come from very cold foods: flavored vodkas and ice cream (especially water ices). In both cases, the flavors are the main point of the food. And when the temperature of vodka or sherbet rises, its taste interest falls. (Clearly, the texture of an ice changes abruptly at 32 degrees Fahrenheit, but it is no great feat to ignore texture in a tasting, and the flavor appea of ices and ice creams does definitely dro as temperature rises.) This happens be cause of the complex physical chemistr that affects our perception of volatil odors.

To begin with, most of what we think o as tasting is actually smelling. This is espe cially true of sensations affected by tem perature: heat increases the volatility o flavors. And that is why cold, which slow down their escape into our olfactory recep tors, reduces flavor intensity, in a genera way. But not all aromatic substances reac to temperature uniformly. Cold stifle some flavors more easily than others.

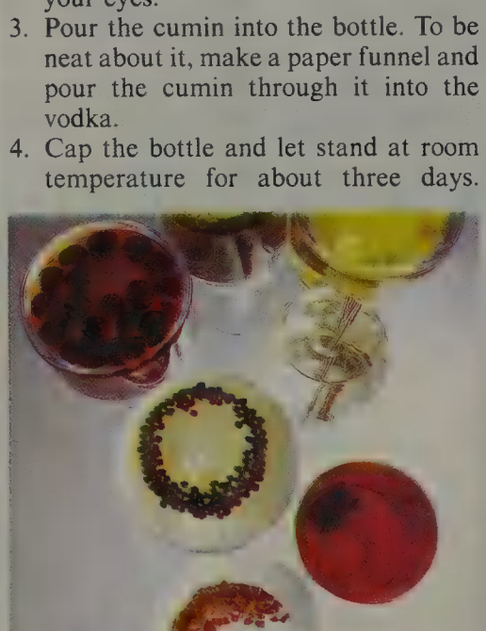
"There's a whole different profile of fla vor at different temperatures," says tast consultant Gail Vance Civille, "differen colors, different notes. Orange juice has different flavor if it's warm or cold."

The Russians who first started flavorin vodkas did not know anything about th olfactory "pictures" that are Civille stock in trade. But they did see that ce tain substances would withstand th damping force of cold and stand out dra matically when the usual elements of voc ka's basic taste were suppressed. They in stinctively chose flavorings of hig intensity, many of them chosen for th

Tex-Mex Vodka

1 quart 80-proof vodka
3 dried red chilies
1 tablespoon ground cumin

1. Open the bottle of vodka.
2. Crumble the chilies and carefully drop the debris, including the seeds, down the neck of the bottle. Now wash your hands. The chilies will have left a residue on your fingers that could burn your eyes.
3. Pour the cumin into the bottle. To be neat about it, make a paper funnel and pour the cumin through it into the vodka.
4. Cap the bottle and let stand at room temperature for about three days. Taste each day to test how well th maceration is proceeding. When tastes just hot enough, strain th vodka, then pour it back into the bo tle.
5. Tighten the cap and put the refille bottle in the freezer. As soon as the li uid is very cold and has turned so vi cous that it pours like a light syrup, it ready to drink. Always serve very col



Richard Jeffery

You can, of course, make a wide rang of drinks in this way. For instance, take vegetable peeler and cut the zest (the co ored surface layer) off one lemon or on orange. Macerate with 2 teaspoons sugar in a quart of vodka for 4 days. Or tr using a dozen berries from a mountain as or 2 tablespoons of caraway seeds, left develop flavor for a week.

Rose Brandy

(From *The Art of Russian Cuisine*, by Anne Volokh, Macmillan, 1983)

25–30 roses, fully opened
3 bottles (750 milliliters each) 8 proof vodka
4 cups sugar

1. Remove the rose petals and place in large jar. Add the vodka, seal the j tightly, and set in a warm place (76 80 degrees Fahrenheit) for 2 to

ne reason as spices or as flavorings in mitive medicines. These flavorings d to be rich in essential oils or acid, ich stand up to cold more fiercely than weaker elements present in vodka.

To test this idea, I cast about for a sub- nce rich in essential oils that had not, so as I knew, been used to flavor vodka. min came immediately to mind. min plants are umbellifers closely re- ed to caraway and fennel. I put cumin o vodka with three dried chilies and ded up with a powerfully interesting nk, the olfactory essence of the Mexi- n border (see recipe).

Lest you think that only taiga-bound ssians and drudges like me fiddle ound with cold-intensified flavor, here is example of peerless elegance in this e. I have it on good authority that the thschilds freeze Château d'Yquem, the eatest dessert wine on the planet, before ey drink it at their own Château Lafite. st before serving, they let the wine de- st to a pourable slush. The cold sup- esses the sweetness and leaves only the ulous bouquet.

aymond Sokolov is a writer whose spe- l interest is the history and preparation food.

weeks. When the liquid turns golden, strain it carefully through 4 layers of cheesecloth.

In a 4-quart enameled pot, make a syrup with the sugar and ½ cup water. Add the rose brandy and bring to a boil. Remove from heat and away from any open fire. Skim the surface. Cool. Pour into bottles, seal tightly, and keep in a cool place for 4 to 6 months.

Yield: Approximately 3 quarts

Sorbet of Apricots à la Moscovite

Based on a recipe from *The Book of Ices,* by A.B. Marshall, London, 1855. Reprinted in *Victorian Ices and Ice Cream,* edited by Barbara Ketcham Wheaton, Scribner's)

⅓ cup plus 1 teaspoon apricot jam
2 tablespoons maraschino liqueur
1 tablespoon rum or brandy
Diced preserved fruit or fresh fruit

Stir the jam together with 2½ cups cold water and push through a fine sieve or purée in a blender.

Stir in the maraschino liqueur and rum or brandy.

Freeze until firm in an ice cream freezer.

Serve with diced fruit.

Yield: About 1 quart

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Summer Brights

by Thomas D. Nicholson

The bright planets are divided between the morning and evening skies this month, but with a little bias toward the morning. Venus and Jupiter are morning stars, Saturn and Mercury evening stars, and Mars goes from evening to morning. During the evenings, when the summertime constellations are up, Saturn is low in the south at sundown and sets in the southwest about an hour after midnight. It's in Libra, about midway between Virgo's Spica and Scorpius's Antares, and about as bright as these two stars. When its retrograde motion ends late in the month, Saturn begins edging toward Antares. Jupiter, on the other hand, is much brighter and more easily seen after it climbs high enough in the west, about three hours past sunset. Since it is still a morning star, Jupiter remains in the sky for the rest of the night. While Venus is well up in the east at dawn, Jupiter hovers in the west until twilight wipes it out. Mercury gives us a fair shot in the evening sky but not its best. If the sunset sky is exceptionally clear, you may see the planet in the west-southwest in late twilight from about March 10 to 20.

The following events are given in eastern standard time unless stated otherwise.

July 1: Tonight's moon might look full, but it isn't. It's half a day shy of being full, and there are two ways you can tell: it rises about half an hour *before* the sun sets, and one portion of it is a bit uneven. Binoculars show it easily. Tomorrow night (*after* full moon) the opposite part of the moon will look uneven.

July 2: Full moon is at 7:08 A.M., and the moon rises about thirty-five minutes *after* sunset.

July 3–4: The gibbous moon is in Capricornus, approaching Jupiter, the bright object to its left. It passes below the planet early in the evening of the 4th.

July 5: Earth is at aphelion (farthest from the sun), but our weather probably won't give you a clue. The slight change of the earth's distance from the sun over the course of the year has little effect on the weather.

July 6–7: The gibbous moon (rising after 10:00) is a good guide to the Square of Pegasus and the star Fomalhaut tonight.

The summer Sky Map identifies constellations and stars for the months of July, August, and September from latitude 40° N at the evening hours given below. To use the map, hold it vertically in front of you with south (S) at the bottom, and match the lower half of the map with the stars you see facing south. As you face in other directions, rotate the map to bring the corresponding compass direction to the bottom of the map.

The stars move west continuously during the night. By morning (before dawn), stars on the western half of the map will have set, those on the eastern half will have moved into the west, and new stars (those of the fall evenings) will have risen in the east. The map represents the sky at about 2:00 A.M. on July 1; 1:00 A.M. on July 15; midnight on July 31; 11:00 P.M. on August 15; 10:00 P.M. on August 31; 9:00 P.M. on September 15 and 8:00 P.M. on September 30. Add one hour for daylight time. The map can be used for an hour or more before and after the times given.

Helmut Wimmer

Look after midnight, when they have risen high enough. The two westerly (right-hand) stars of the Square are above the moon and Fomalhaut is below.

July 9: Last-quarter moon is at 7:39 P.M. It rises close to midnight in Pisces.

July 10–11: The waning crescent moon, now in Aries, rises shortly after midnight. It reaches apogee (farthest from earth) at 3:00 A.M. on the 11th.

July 13: Mercury is at its greatest distance to the sun's left (greatest easterly elongation) today, placing it in its best position as an evening star when the sun sets. But best isn't good enough this time. The planet may be seen low in the west during twilight for a week or so before and after the 13th, but it won't be easy.

July 13–14: The morning crescent moon joins Venus in the eastern sky. Both rise before dawn and are well up before twilight obscures them. The moon slowly approaches Venus on Saturday morning and passes north of the planet on Sunday morning.

July 15: Still near its prime as a morning star, Venus majestically drifts past Aldebaran, the bright ruddy star of Taurus. But even Aldebaran pales in Venus's brilliant glow. A glimpse at the rising crescent moon, below and to their left, may be the last before new moon.

July 17: New moon, at 6:56 P.M., is near Gemini's border with Cancer. Mars is finally in conjunction with the sun.

July 19: The young crescent moon shows up tonight in Leo, in front of the Lion's mouth. Regulus, the bright star at Leo's heart, to the moon's left, is easier to see. The conjunction of the moon with Mercury won't help much in finding the elusive planet, far south of the crescent.

July 20–23: Not much happening these days, except the crescent moon is fattening and slowly drifting east through Leo and Virgo. But it does wonders for a clear summer's evening to see that crescent up there from twilight into the dark of night. Try following the moon nightly as it drifts away from Leo and Regulus, in the west, toward Virgo's bright star Spica, high in the south.

July 23–24: The moon shifts from Spica's right to its left these nights. The cres-

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cent becomes the first-quarter moon at 6:39 P.M. on the 24th.

July 25: The moon is at perigee in Libra, near Saturn. Early on Friday morning, the moon passes Saturn, but after the two have already set.

July 26: Saturn ends its retrograde (westerly) drift through Libra, signaling that its sojourn as an evening star is soon to end. Mercury, on the other hand, signals the end of its evening performance by beginning its retrograde motion today.

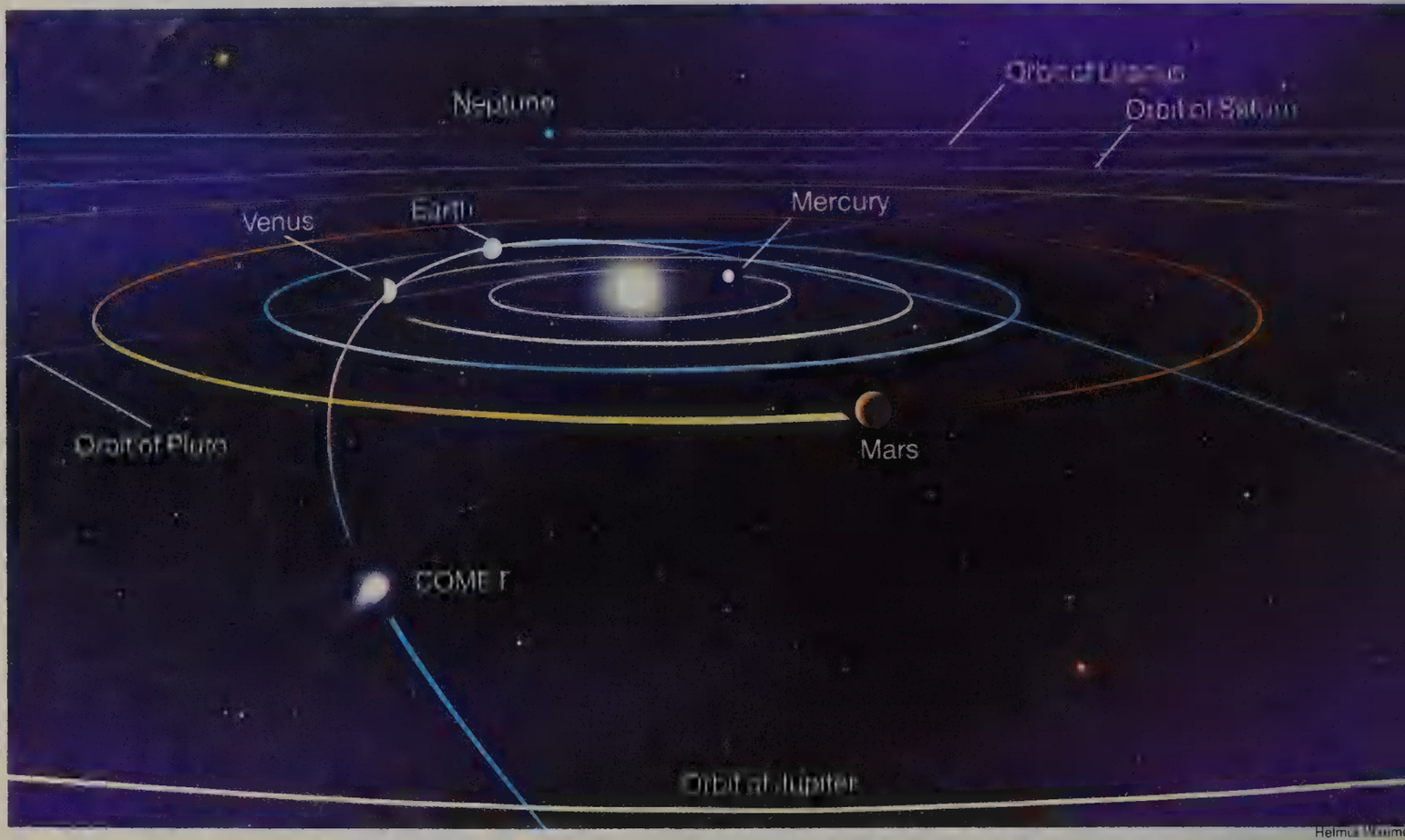
July 27: The reddish star to the moon's right is Antares, in Scorpius.

July 28: The southern Eta Aquarid meteor shower—broad, sparse, relatively slow, and dim—is at maximum today. Not too great a display, but with the moon setting about 1:00 A.M., dark skies should help see the shower.

July 29: The gibbous moon is in Sagittarius, but it is not yet bright enough to hide the stars of the Teapot, below and to its right.

July 31: The second full moon of the month is at 4:41 P.M., in Capricornus. Note that the earlier one was in Sagittarius, about one-twelfth way around the sky to the west. The bright object above the moon is the planet Jupiter.

Halley's Comeback



Halley's comet is now in Taurus, where the "heliacal rising" occurs each year in July. The term designates the rising of a star when it is first seen again after being invisible due to its nearness to the sun. The stars of Taurus rise in the east just before dawn. The sun, which passed through Taurus about a month earlier, rises about two hours after this star group during July.

Taurus, with its bright red star Aldebaran, is well known as a winter constellation. In winter, the sun is halfway around the sky away from the group; it rises in the early evening and is part of the sky scene all night long. Between now and then, Taurus, with Aldebaran as its "point star," rises earlier each day, remaining visible for longer in the morning sky before the brightness of twilight wipes it out.

If it didn't enter the sky so close to dawn, Zeta Tauri (the third-magnitude star at the tip of Taurus' left horn) would be an excellent marker to help searchers find Halley's comet with large telescopes. But star and comet rise too late and the comet is too faint to make trying worthwhile this month.

Late in July, the comet moves into Gemini, very near the summer solstice, the point in the sky where the sun is on June 21. It ends its retrograde motion in September and swings west again through Taurus, remaining within the boundaries of the constellation for several more months. The stars of Taurus move into better position for viewing in the months ahead, and so does Halley's comet. Beginning in August, amateur astronomers may have a good chance of spotting the comet.

The comet is still doggedly edging its way closer to the sun in July, cutting the distance by more than thirty million miles. Under the acceleration of gravity, its speed continues to build to more than 45,000 miles per hour. In this month's illustration, the comet is very nearly on the opposite side of the sun from Earth. But it is moving to the right around the sun, while Earth is moving to the left. The motions of the earth and the comet take them closer to one another, and that will continue until the close pass of November 27. This month, the distance between Earth and comet decreases by more than 55 million miles. At midmonth the comet is 389 million miles from the earth, 307 million miles from the sun.

Note that I referred to the easterly motion of Halley's comet during its retrograde loop. The retrograde motion of all the planets is westerly, of course. The diagram shows why. The comet's motion is opposite to the orbital motion of the planets. So the comet's direct motion is westerly, and when it retrogrades it appears to turn in an easterly direction.

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The Amagansett Whale

The American Museum of Natural History's collection of whale skeletons is stored in an echoing, cavernous space. This cement and brick building previously housed the huge generators that powered the Museum's complex of buildings. Today, instead of humming generators, the room is filled with enormous plastic-shrouded skeletons of whales. The ceiling is still a tangle of metal tracks and winches, once used for moving the powerhouse machines but now used for shifting the skeletons of the leviathans.

Although the Museum's collection of the larger whales contains only about a dozen specimens, it is one of the biggest in the world. (The entire collection also contains several dozen smaller whales and more than 400 other cetaceans.) Whales are the biggest animals that have ever lived—bigger even than the dinosaurs o mammoths—and they are a formidable challenge even for major museums.

The Museum's first important whale came from Amagansett, Long Island. I was obtained by two young men—Roy Chapman Andrews and James L. Clark—both of whom would later become well known as explorers.

Andrews got into whale collecting by accident. In 1906, when he began working at the Museum as a part-time floor washer, the institution possessed only a few miscellaneous whale bones. Nevertheless, Museum director Hermon C. Bumpus decided to create and exhibit a full-size replica of a great blue whale. He hired a whale expert to build the creature and pulled Andrews away from his janitorial duties to be the man's assistant. He also

At the American Museum

Planetarium Events

Starting June 27, the Hayden Planetarium will feature two new sky shows. The first, *Hayden: The Golden Years,* celebrates the Planetarium's fiftieth anniversary. It looks back on five decades of astronomical history, examining how our perceptions of the universe have changed; then looks ahead to the next fifty years to what we may yet discover. The second show, *Halley's Comet: Once in a Lifetime,* tells where and when to look for Halley's comet. It will also explore the nature of comets and discuss how scientists will use Halley's return as an opportunity to study a comet in more detail than ever before. For more information and show times call (212) 873-8828.

Native American Month

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Living Museum

signed Andrews's roommate and friend, mmy Clark, to the project.

The replica was a disaster. The model-aker tried to construct it by covering a ood-and-iron framework with paper. But e paper sagged and buckled between the os, giving the animal an emaciated ap-earance. After weeks of watching the an try to prop up the pathetic-looking hale, Bumpus finally lost his patience. ccording to Andrews's book, *Ends of the arth,* the director called Andrews and lark into his office and said, "This whale getting on my nerves. It is beyond all en-urance. What shall we do?" The two oung men immediately recommended at Bumpus fire the whale expert and re them to finish the job, using papier âché instead of paper. Bumpus agreed.

In 1907, while Andrews and Clark were

e People Center. Each weekend, dance nd theater performances, lectures, dem-nstrations of crafts and examples of Na-ve American music will be featured om 1:00 to 4:30 P.M. The programs are ee and visitors may drop in at any time.

rt of the Cameroon

On July 15, a new exhibition, *Art of the Cameroon,* will open in Gallery 1. Most of he one hundred and fifty pieces on dis-lay date from the turn of the century and re from the traditional royal courts of Cameroon's savanna region. Among hem are sculptures, baskets, figures, and ewelry. Many of the items have been bor-owed from private and public collections n America and Europe, as well as from he private collections of the *fons* (kings) f the Cameroons. Highlights of the show nclude a feather cape and a number of ood sculptures intricately decorated ith colorful beads. The exhibition, which being circulated by the Smithsonian In-titution Traveling Exhibition Service, is upported by a grant from the Mobil Cor-oration. It will remain open until Octo-er 15.

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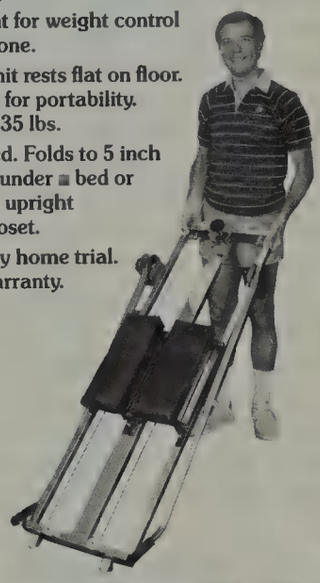

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building the whale (it would hang in the Museum for half a century before being replaced with a bigger model), a record-size Atlantic right whale was killed off Long Island. Bumpus decided he wanted to preserve the complete skeleton with its baleen (the long, fringed, platelike sheets of horny, elastic material that some whales use to filter plankton from the water while feeding) for the Museum. He dispatched Andrews and Clark to Amagansett, where the whale had been brought ashore.

When they arrived at the town, they sought out Josh Edwards, the 76-year-old retired sea captain who had harpooned the whale from a shore-launched boat, and Andrews negotiated to buy the whale's remains. In those days, baleen, an essential component of women's corsets, was extremely valuable. Therefore the sum of $3,200—very high in turn-of-the-century dollars—was finally settled upon as a just price for the baleen; Edwards threw in the rest of the skeleton "for free."

Andrews and Clark found the whale lying near the low-tide mark, partly awash in the surf. Since fishermen had already stripped off its blubber and flukes, the whale was a grotesque-looking pile of meat, and it took several minutes to distinguish the head from the tail. The fifty-four-foot skeleton was still buried in about fifty tons of flesh. Waves washing over the carcass had left it glazed with ice.

To help them carve the meat off the skeleton, Andrews and Clark hired a half-dozen local fishermen. The men set to work on the carcass with long knives, slicing off giant sections of meat so heavy they had to be dragged from the body with a horse, grappling hooks, and rope.

On the the third day, a storm beat down from the east. "We saw it coming," Andrews wrote,

and anchored our whale as best we could, working waist deep in the icy water. For three days the shore was a smother of white surf. Anxiously we waited . . . . The fourth day was dead calm but very cold; twelve degrees above zero at noon. When we got to the beach, a smooth expanse of sand, innocent of whale, met our eyes. The bones had disappeared.

After a moment of horror, Andrews and Clark realized that their anchor ropes were still in place but buried in the smooth sand. They began digging into the beach, and soon the carcass came to light. "As soon as we dug out a shovelful of sand to get at a bone," Andrews wrote,

the depression filled with water. We had to grope blindly with small knives, our arms i the freezing water up to the elbows, to di articulate each vertebra. None of the fish ermen would work at any price. It seeme hopeless and I don't mind saying that never have suffered more in any experienc of my life than I did then. But the directo told us to get every bone and we simpl couldn't give up.

At last some of the fishermen decided t help when they saw us two kids strugglin hopelessly in that icy water . . . . At the en of a week a huge pile of bones lay well u along the beach.

Andrews and Clark made an inventor of their find, checking each bone against drawing of a right whale skeleton owne by the Smithsonian Institution. Much t their disappointment, several cruci bones were missing—including the tw slender vestigial pelvic bones (evolutio ary remnants of the hip bones of th whales' land-dwelling ancestors). "Searc as we could," Andrews wrote, "Jimm and I could not find those wretche bones." Suddenly, it occurred to Andrew that the bones could have come off wit the blubber and might be found at the tr works (a brick furnace where blubber rendered). They arrived there just after load of blubber had been dumped into a

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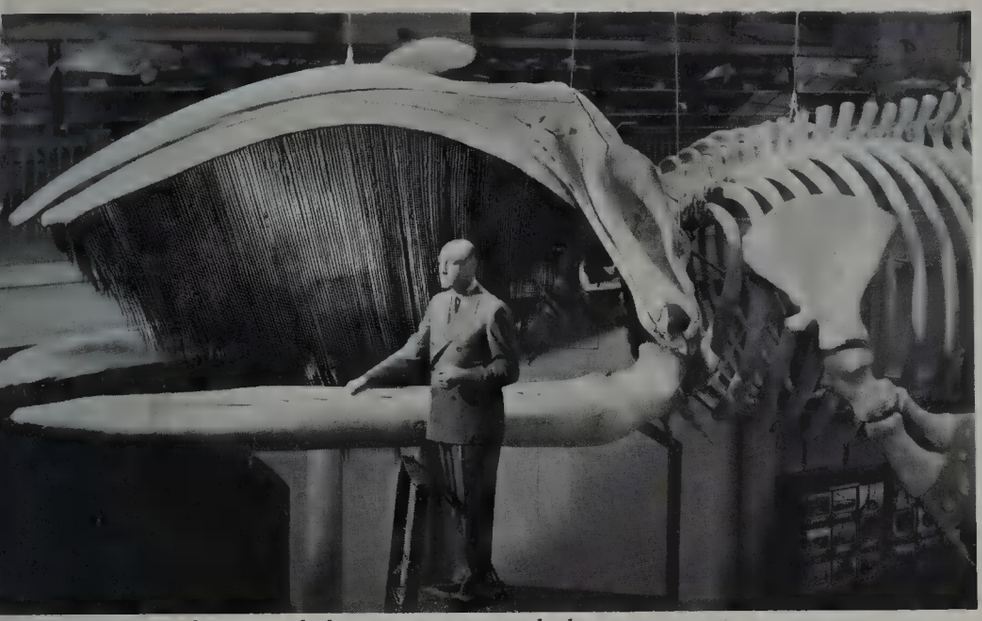

y Chapman Andrews and the Amagansett whale

n vat, and Andrews fished around in the
bbling fat with a net. Soon, he had
gged not only the two pelvic bones but
o several smaller bones known as the
horal rudiments. Rarely preserved in
seum specimens, these were important
evolutionary studies.
The Amagansett whale was a female,
d after she was killed the fishermen no-
ed a calf swimming aimlessly along the
ore. A short time later the calf was har-
pooned near Wainscott, Long Island, and Andrews purchased its skeleton as well. It was later traded to the British Museum (Natural History) for the skeleton of a dodo bird, now on display in the Biology of Birds Hall.

Both whale skeletons—partly disarticulated—were hauled to the railroad station by horse-drawn cart and shipped to New York via the Long Island Rail Road. Once at the Museum, the bones were further cleaned, boiled in maceration vats, and degreased with benzene. Finally they were neatly numbered and installed in the Museum's storerooms.

Because Andrews had secured the whales for the Museum, Bumpus rewarded him with a scientific plum: Andrews was allowed to be the first to study the rare specimen. Later, he led several expeditions to Japan, China, and other areas in the Far East to collect more specimens from whaling operations. While in China, Andrews conceived the Museum's Central Asiatic Expedition, one of the most important in the history of natural science (see "A Nest of Dinosaurs," *Natural History,* March 1985).

The bones of the Amagansett whale rested in the Museum's storeroom for many years before they were dusted off and mounted for exhibition. Finally, in 1934, the grand skeleton was hung in the Museum's Hall of Ocean Life. It remained on display until the 1960s, when the Museum's ninety-four-foot model of the great blue whale was set up. Today the bones are stored in the old powerhouse, together with the rest of the whale collection, an important resource for scientists all over the world.

Douglas J. Preston

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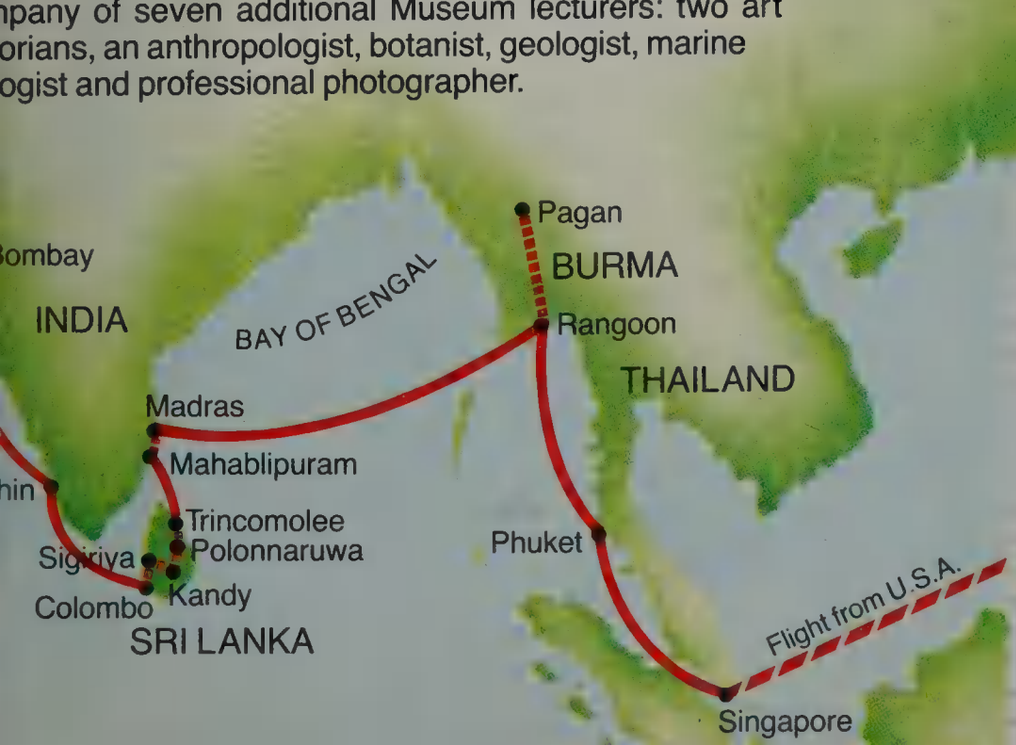

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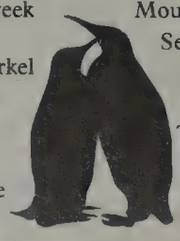

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Bee-eaters "come [across] as alert and vivacious birds," wrote Scottish ornithologist Hilary Fry, and that may be a mild way to describe birds that routinely blast out of their nests like rockets. Most of the twenty-four species are extremely active, foraging for honeybees and social wasps during most of the daylight hours. Carmine bee-eaters, according to Fry, often don't even bother to perch when they're foraging. Like swallows, they stay aloft, "sailing around leisurely and . . . with a few quick beats, effortlessly twisting after an insect."

The rainbow bee-eater, shown here, is native to Australia. It's a gregarious bird that nests colonially in sandy plains, earthworks, gravel heaps, and roadside and river banks. The nest tunnels are often dug into flat ground and occasionally into sand cliffs. Both sexes do the digging but have a habit of making false starts, repeatedly abandoning one effort to begin another. "These false starts seem to be a pointless waste of effort and a study of the problem is needed," Fry wrote in his book *The Bee-Eaters,* published last year.

When finished, the tunnel is usually more than three feet long, and when it is built in flat ground it generally slopes down to a depth of about sixteen inches. The egg chamber at the end of the tunnel is about sixteen inches long, eight wide, and three high. A female rainbow bee-eater usually lays four or five eggs. She, her mate, and often, male helpers take turns incubating them.

In some parts of Australia, people consider the arrival of big flocks of rainbow bee-eaters the official beginning of spring. Bert Wells and his wife, Babs, celebrated the new season recently by setting up camera equipment and a high-speed flash outside a nest tunnel near their home in Western Australia and taking, as he says, "one of our best shots ever."

Photograph by Bert Wells

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Additional Reading

Floral Scents (p. 28)

Coevolution of Animals and Plants, edited by Laurence E. Gilbert and Peter H. Raven (Austin: University of Texas Press, 1980, paperback), includes a pertinent review of the biochemical coevolution of plants and herbivores. It discusses ant–plant interactions, as well as the scent of orchid flowers and its effect on the bees that visit the plants. Ann H. Zwinger and Beatrice E. Willard's *Land Above the Trees* (New York: Harper and Row, 1972) is a gracefully written introduction to the natural history of alpine Colorado. *Flower Pollination in the Phlox Family*, by Karen A. Grant and Verne Grant (New York: Columbia University Press, 1965), surveys the various pollinators of phlox flowers and analyzes the natural history and adaptations of the flowers. Peter G. Kevan and Herbert G. Baker's "Insects as Flower Visitors and Pollinators" (*Annual Review of Entomology,* vol. 28, pp. 407–53) explores the different kinds of insects that visit flowers, focusing on pollinators.

Maori (p. 36)

Michael King's *Maori: A Photographic and Social History* (Auckland: Heinemann Publishers, 1983), a comprehensive history of the Maori people, has a wide range of pictures that illustrate almost every aspect of Maori life since the advent of photography. The greater part of the book records how Maori life changed in response to the arrival of Europeans in New Zealand and how Maori culture managed to remain intact. *Natural History*'s last article on the first New Zealanders, "Maori Power" (September 1984, pp. 54–59), with photographs by Athol McCredie, announced the national tour of "Te Maori," an exhibition that marked the first time the Maori had allowed their traditional artworks to travel abroad. *Te Maori: Maori Art from New Zealand Collections* was the accompanying catalog (New York: Harry N. Abrams, 1984). In *The Maori: Heirs of Tane* (London: Orbis Publishing, 1982), David Lewis tells the story of the Maoris' arrival in New Zealand some time after A.D. 750, and traces their history as hunters and fishers and, later, in the twelfth and thirteenth centuries, as farmers. Lewis investigates this new agricultural system, which led to a way of life structured around extended family clans and governed by gods, and follows Maori history to the nineteenth century, when the Europeans arrived in New Zealand.

El Chichón (p. 46)

The December 1984 *Journal of Volcanology and Geothermal Research*, edited by J.F. Luhr and J.C. Varekamp (published by the Elsevier Scientific Publishing Co., 52 Vanderbilt Avenue, New York, New York 10017, 212-916-1250), devoted to the eruptions of El Chichón. It contains eight articles by specialists in volcanology, geochemistry, and atmospheric science on such subjects as the relationship between explosive volcanism and the earth's climate; the stratigraphy of pyroclastic deposits; the character of the eruptions, ash fall deposits, and gas phase; and the nature of the stratospheric cloud. *Geofísica Internacional,* a Mexican scientific journal, also published a special issue (vol. 23) on El Chichón, with fourteen articles (in English) on the effects of the eruptions. Write to the Universidad Nacional Autónoma de México, Instituto de Geofísica, Circuito Exterior, Mexico 20, D.F., Mexico, for more information. Although the eruptions of El Chichón were relatively small, they injected a volcanic cloud into the stratosphere denser than any since the eruption of Krakatau in 1883. Michael R. Rampino and Stephen Self consider the climatic implications of the eruptions in "The Atmospheric Effects of El Chichón" (*Scientific American,* January 1984, pp. 47–57). In November 1982, *National Geographic* ran two articles on El Chichón: Bonfil Weintraub's "The Disaster of El Chichón" (pp. 653–71), which considers the economic as well as the atmospheric impact on people, and Robert I. Tilling's "Volcanic Cloud May Alter Earth's Weather," (pp. 672–75). Both are illustrated superbly.

Hummingbirds (p. 56)

Alexander F. Skutch has studied hummingbirds in their native homes in tropical America for more than forty years, and his book *The Life of the Hummingbird* (New York: Vineyard Books, 1973) is one of the better introductions to these birds. The book is nicely illustrated by Arthur B. Singer. Skutch's *Naturalist on a Tropical Farm* (Berkeley: University of California Press, 1980) describes his life on a farm in southern Cost

ca. Although nearly all the surrounding odland has been destroyed by agricul-e, he has managed to preserve a large ct of tropical rain forest. Paul A. nsgard's *The Hummingbirds of North nerica* (Washington: Smithsonian Insti-ion Press, 1983) is one of the more thor-gh works on these birds. It summarizes ir comparative biology (including evo-ion, anatomy, ecology, behavior, and productive biology) and their natural tories. *Hummingbirds: Their Life and havior* (New York: Crown Publishers, 85) includes 235 full-color photographs Robert A. Tyrrell, including never-be-e photographed sequences of nesting, lting, preening, and territorial aggres-n, as well as a portfolio of hum-ngbirds feeding from wildflowers. The t, by Esther Quesada Tyrrell, admira-presents up-to-date information on the al statistics of each of the North Ameri-n species, but it is the photographs that ke this book stand out. Larry L. Wolf d F. Reed Hainsworth compiled and edited articles from a symposium on the ecology and behavior of nectar-feeding birds; you can find these in the *American Zoologist*, vol. 18, pp. 618–819. One of the best books on mites to start off with is Asher E. Treat's *Mites of Moths and Butterflies* (Ithaca: Comstock, 1975). Treat, a New England naturalist, is known in the mite field for his discovery that mites of the species *Myrmonyssus phalaenodectes* infest the "ears" of the army worm moth, destroying their tympanic membranes. Interestingly, the mites confine their damage to only one ear. The book's first chapter is particularly recommended; it is one of the better introductions to mites around. Robert K. Colwell's "Competition and Coexistence in a Simple Tropical Community" (*American Naturalist*, vol. 107, pp. 737–60) is a readable description of interactions between mites and hummingbirds. Colwell will contribute "Community Biology and Sexual Selection: Lessons from Hummingbird Flower Mites," a more technical version of his article in this issue, to a book due out at the end of this year; titled *Ecological Communities*, it is being edited by Ted Case and Jared M. Diamond. David S. Dobkin conducted an interesting experiment on how mites react to the microclimate inside flowers. After inserting tiny wires, called thermocouples, that accurately indicate temperature, inside the flowers, Dobkin then manipulated the temperatures and recorded the mites' reactions. He explains his research in "Heterogeneity of Tropical Floral Microclimate and the Response of Hummingbird Flower Mites" (*Ecology*, vol. 66, pp. 536–43). Among the many books on pollination, we recommend the following: *The Sex Life of Flowers*, by Bastiaan Meeuse and Sean Morris (New York: Facts on File, 1984); *Pollination Biology*, edited by Leslie Real (New York: Academic Press, 1983); and *Handbook of Pollination Ecology*, by C. Eugene Jones and R. John Little (New York: Van Nostrand Reinhold, 1983).

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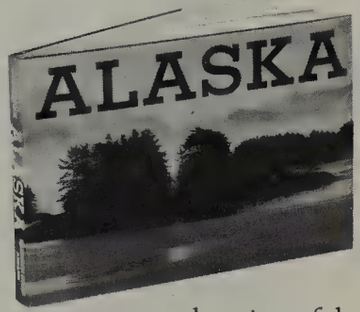

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Authors

Nearly seven years ago, **Candace G len** (page 28) realized that the sky pil one of central Colorado's most acc sible and abundant tundra plants, w more than "just another pretty face" the region's crowd of alpine wildflowe Why, she wondered, did some of t plant's flowers smell sweet and oth skunky? Galen's work on the plant led a Ph.D. from the University of Texas Austin. Now a postdoctoral fellow at t University of Toronto, Galen is condu ing field and laboratory studies of the namics of bumblebee–plant relati ships in eastern Ontario. In Septemb she will begin duties as an assistant p fessor at Bowling Green University Ohio. Galen's diversions include mou taineering, rock climbing, fishing, wr ing poetry, playing clawhammer ban and juggling.

Michael King (page 36), a New Z land historian, has been writing abo the Maori for more than a decade. 1983, he published his most recent a controversial book, *Maori: A Pho graphic and Social History.* "The c troversy was not about the writing or t history," notes King, "but over whet non-Maori should still be writing Ma history in light of the current drive ward cultural self-determination. In

mosphere that now prevails, non-aori writers on Maori topics are aded toward obsolescence." King, no has a doctorate from the University Waikato in New Zealand, has worked rd at taking New Zealand history out the universities and back into the com-unity. He has won awards for earlier ojects in history and journalism, as ell as for his work in television docu-entaries.

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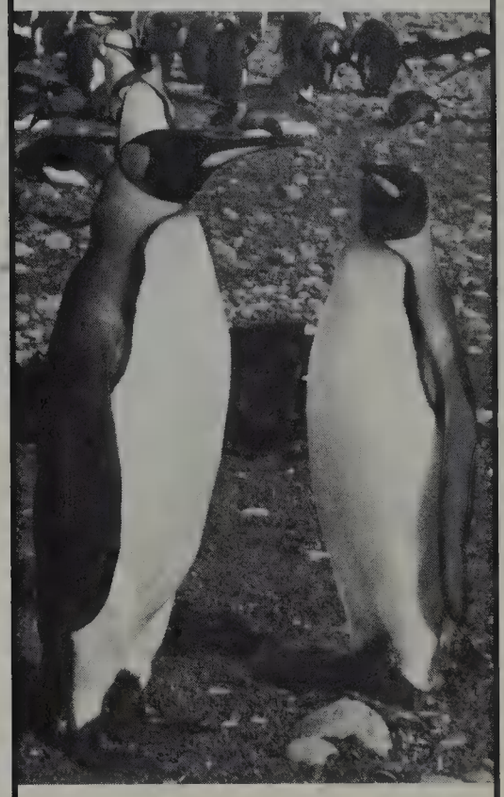

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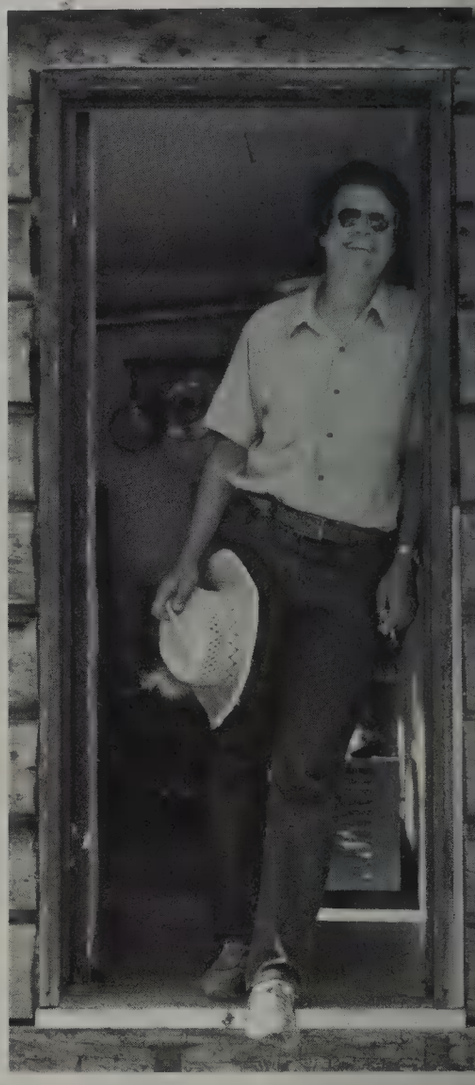
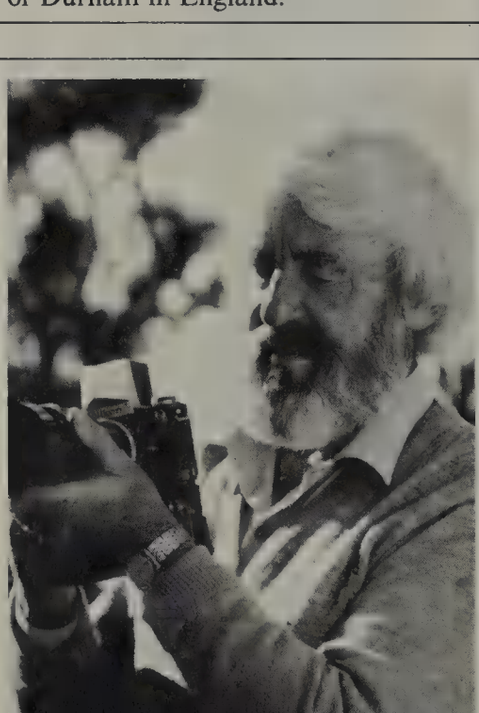
The last time *Natural History* readers heard from volcanologist **Haraldur Sigurdsson** (page 46) was in March 1982, when his article "In the Volcano" appeared. At the same time, a newly active volcano in Mexico hit the headlines—El Chichón. In this issue, Sigurdsson reports on the scientific expeditions that followed once things had quieted down. The photo shows him (center) with coauthor **David Gardella** (right) and another member of the research team, Steven Carey. They are breakfasting at their ash-covered headquarters, five miles from El Chichón's crater. Born in Iceland, Sigurdsson is a professor at the University of Rhode Island's Graduate School of Oceanography, where he combines teaching with research on the mineralogy and geochemistry of volcanic rocks. He has investigated numerous volcanoes, on land and in the ocean basins. David Gardella, who participated in the expedition to El Chichón, works in Massachusetts as a writer and sales manager. He first met Sigurdsson when they were graduate students at the University of Durham in England.



Most people live all their lives without giving a thought to hummingbirds' nostrils, much less to the fauna therein. They haven't met **Robert K. Colwell** (page 56), who presents the "other world" of hummingbird flower mites with you-are-there freshness in this issue. Now a professor of zoology at the University of California at Berkeley, Colwell has been a visiting professor at universities as far afield as Texas, Sweden, and Chile and has carried out field studies in Latin America and the Caribbean. His present interest in the evolution and ecology of biological communities, particularly the relationship of arthropods, such as mites, to plants and vertebrates, grew out of his work in Costa Rica, a home of his namesake, the mite *Rhinoseius colwelli*. Curiosity and love of nature run in the family. In Kenya, at the age of four, Colwell's daughter, Emily, "collected" an aloe flower for him; inside they found the first Kenyan sunbird flower mite known to science.

Bert Wells (page 82) became a naturalist-photographer in 1970, mainly to escape a boring job in the city. He quickly gained numerous international awards, including the Award of Excellence from the International Federation of Photographic Art in Switzerland, and a listing in *Who's Who in Photography,* published by the Photographic Society of America. His wife, Babs, is a field ornithologist, and Wells relies on her to point him in the right direction when they're out in the bush of Western Australia. Their most recent work was *The Wild Pilbara,* a photographic study of Western Australia's rugged northwest region. Wells's shot of a rainbow bee-eater blasting out of a nest tunnel, in this month's "The Natural Moment," was taken with a high-speed flash (1/10,000 of a second) and a 35-millimeter lens.



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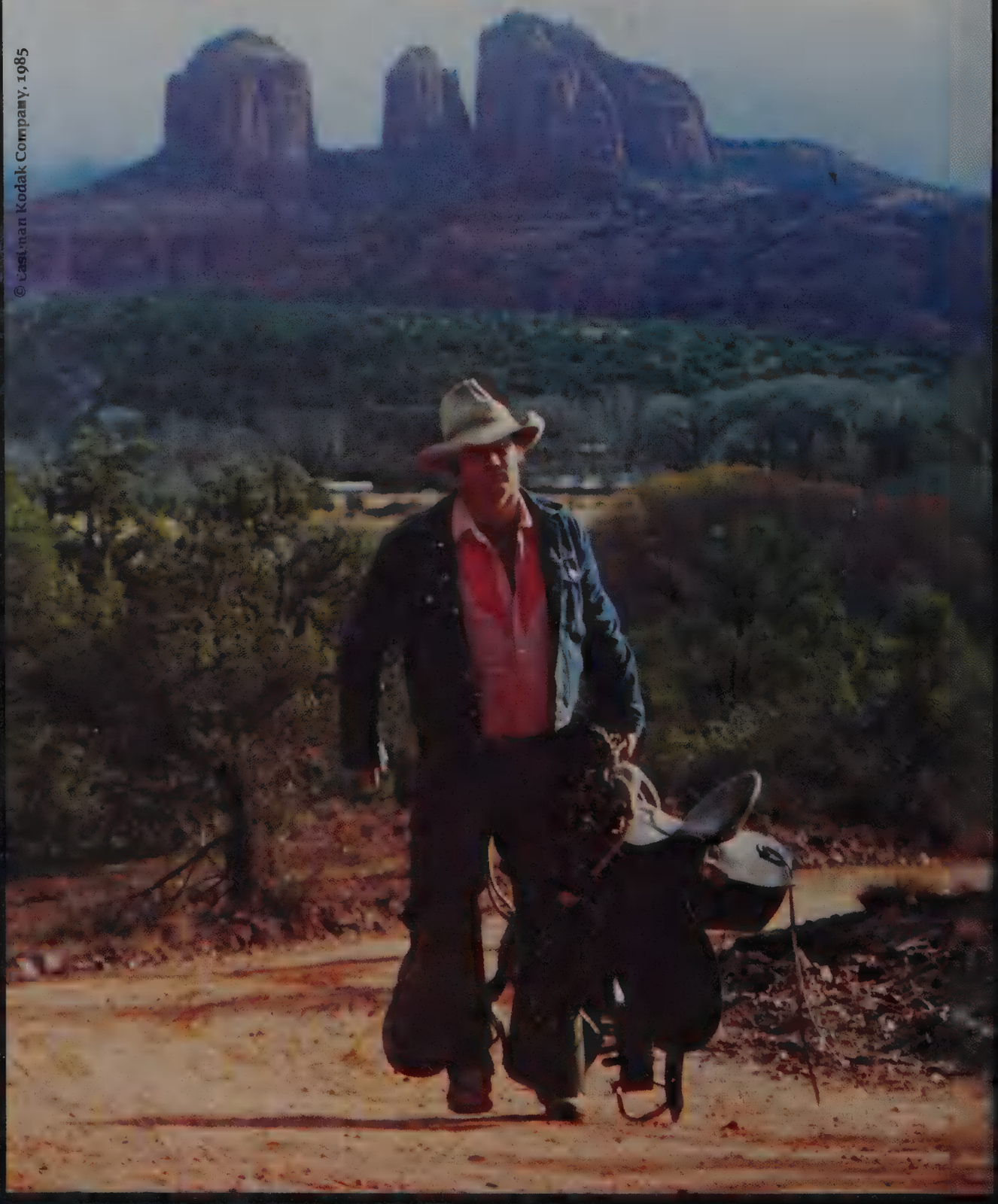

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Vol. 94, No. 8, August 1985
American Museum of Natural History, New York, N.Y.
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NATURAL HISTORY *(ISSN 0028-0712) is published monthly by the American Museum of Natural History, Central Park West at 79th Street, New York, N.Y. 10024. Subscriptions: $20.00 a year. In Canada and all other countries: $26.00 a year. Second-class postage paid at New York, N.Y. and at additional mailing offices. In Canada second-class postage paid at Windsor, Ontario (permit no. 9579).*

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Natural History *is indexed in* Reader's Guide to Periodical Literature.

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yers and Slappers

I don't know anything about Mormon cones" ("A Matter of Taste," June 985), but I do know about American In- an fry bread. Mr. Sokolov hit the nail on e head when he related it to the French *eignet*. The one true original Indian fry ead began among the Indians of the reat Lakes, who were educated in cook- g and theology by the French missionar- s. Wheat was unknown to the Algonkian nd Siouan tribes of the Lakes area. So as frying. Combined, as in the *beignet*, ey were irresistible, and Indian women ught on quickly. Fry bread spread east- ard to the Atlantic and southward down e Mississippi drainage. It is even possi- e to classify Indian women as fryers and appers. Slappers adopted the Mexican ethod of slapping unraised corn dough etween the palms, thus producing torti- as. Fryers need little explanation, beyond dding that they use raised dough.

The Navajo slap out tortillas and cook em on flat stones, preferably soapstone abs. Since World War II, when Navajo rvicemen met up with servicemen from ther tribes, women have made fry read—not "fried bread," Mr. Sokolov— r festive occasions.

ALICE MARRIOTT
Oklahoma City, Oklahoma

exual Stereotypes

"Superheroes in the Doll Corner," by ivian Gussin Paley (March 1985), pre- nts what I think is a false picture of "sex- al self-stereotyping." Ms. Paley presents e behavior of kindergarten boys and irls as if it arose naturally with no influ- nce from the environment; as if the chil- ren created the sex roles themselves, ather than picking them up from the ex- mples set for them from birth.

Her article tacitly presumes this is na- ure taking its course. I propose an alter- ate explanation: at this age children be- in to identify themselves with the stereo- ypes they have been presented with since irth. Sexual stereotyping is so insidious in his society that we don't even notice it ost of the time, but a close examination f television commercials and children's rogramming (adult programming, too, r that matter), storybooks, even science ooks shows males as active, females as se- ate; men as saviors, women as victims. here is no other paradigm available to he developing child.

RENNY CHRISTOPHER
Gilroy, California

Vivian Gussin Paley replies:

Renny Christopher blames the biases of adult society. Others find explanations for the differences between boys and girls in biological fact or psychosexual theory. Without rejecting any of these approaches, I offer still another piece of the truth: group consciousness.

Boys and Girls follows a class of kindergarten children as they respond to the newest, most exciting phenomenon in their lives, the emerging separate-sex peer group, which they define primarily in terms of its fantasy play. My purpose is to describe this remarkably different play and to suggest that, in the classroom, boy–girl differences are not as important as the adult's attitude toward those differences.

Rhesus Recovery

Dr. Siddiqi and I wish to go on record as having several objections to the editorial treatment accorded our article on rhesus monkeys (February 1985). The title, "The Rhesus Monkey's Fall from Grace," is inappropriate because the rhesus monkey is a sacred species and therefore cannot "fall from grace." People of all religions may modify their behavior under economic pressure; but for many Hindus the rhesus remains a sacred species. The title selected by *Natural History*'s editors confuses religious values with economic pressures and agricultural expansion. The subtitle, "There is little place left in modern India for a sacred species," gives the wrong impression. We have maintained for years that India *does* have a place for a sacred species and we have written and spoken often of the extensive areas where the rhesus can thrive without excessive economic problems. In addition, we have proposed ways to reduce agricultural conflicts.

Two of the captions are misleading: We have not documented extensive decline of the rhesus in Nepal and have, in fact, noted the stability of the rhesus there; and we would never refer to the rhesus as being "ubiquitous" in the cities of India, nor would we compare them with "pigeons in New York."

In our opinion, the selection of photographs misrepresents our research and the article's intent. Our studies concentrated on agricultural environments, not temples or cities, as shown on the cover and in five out of six photographs in the article. We do not want to perpetuate the myth that most rhesus in India are associated with

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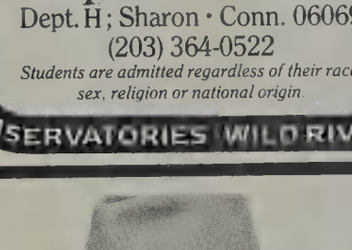

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temples. Finally, the names of two of our respected colleagues in India—Dr. K.K. Tiwari and Dr. R.P. Mukherjee—were misspelled.

We would also like to add that although declining primate populations were of concern to the government of India, the key factor precipitating the export ban on primates was the demonstration by the International Primate Protection League that rhesus monkeys were being used in the United States for inhumane laboratory experiments. The failure to include this was our omission.

After twenty-six years of work in India, we are distressed by these misleading impressions and hope that this letter will clarify our position.

CHARLES H. SOUTHWICK
Professor of Biology,
University of Colorado,
Boulder, Colorado

Jacobson's Organs

In "A Bite to Remember" (April 1985), Robert K. Colwell refers to the heat-sensing pits of *Bothrops asper* as Jacobson's organs. This is not so.

The Jacobson's organs are two pits located in the roof of the mouth. The tongue picks up external material particles and transfers them to the Jacobson's organ, which then transmits the resultant sensations to the brain. The Jacobson's organ should, therefore, be considered as an organ of taste; it has nothing to do with temperature perception.

It should also be noted that heat-sensitive pits are found in pit vipers, while the Jacobson's organs are found in all snakes and lizards.

JOHN O. HOLLISTER
San Antonio, Texas

Robert K. Colwell replies:

Mr. Hollister is correct. An early draft of the article pointed out that vipers use *both* the heat-sensing loreal "pits" *and* the chemosensory Jacobson's organs to detect prey, but the two were somehow confounded during the process of revision and I failed to catch the error.

In Defense of Coconuts

As a consultant to the Philippine coconut industry since 1962, mostly unpaid or underpaid, I have kept abreast on current developments in microbiology and nutrition regarding the coconut and its products. In this connection I have read, with considerable consternation, "The Perilous Seed," by Raymond Sokolov.

In most instances the intake of coconut meat, either fresh or desiccated, or of unmodified coconut oil as part of a normal diet containing adequate levels of the essential fatty acids has no evident disadvantage. Thus, it should not be compared to diets rich in cholesterol and coconut oils solidified by chemical hydrogenation. Finland, where the population consumes the fattiest diet in the world, principally of animal origin, exhibits the highest incidence of coronary heart disease and stroke. By contrast, the Philippines, Indonesia, and Thailand, where coconut is the major dietary fat, exhibit a significantly lower incidence of heart disease and stroke than many other countries.

CARL P. SCHAFFNER
Professor of Biochemistry-Microbiology
Rutgers University
Piscataway, New Jersey

More Clock of Evolution

In "A Clock of Evolution" (April 1985), Stephen Jay Gould describes studies of bird phylogeny based on DNA-DNA hybridization. Gould claims that through such work "the problem of phylogeny has been solved" and that he "does not fully understand why we are not proclaiming the message from the housetops." The explanation is simple: any such proclamation would be at best premature and at worst fallacious. Gould states that "the decoding of phylogeny requires no more than a method for recognizing homology and eliminating analogy." More is, in fact, required: primitive homologous similarities must be distinguished from recent ones. Doing this for distance data (like the bird DNA annealing values) is problematical. For example, the phylogenetic trees constructed from such data attempt to account for the observed "distances" between species; the greater the distance, supposedly, the more ancient the common ancestry. But the phylogenetic trees that best fit observed data sometimes require species to be separated by negative, rather than positive, distance values. This result is farcical (common ancestors don't really live in the future) but itself provides evidence that DNA annealing distances are not clocklike. Such anomalous results could be attributed to sampling or measurement error, but if the data are subject to such error, they are not a reliable guide to phylogeny, much less the panacea Gould envisions.

Phylogenetic analyses of actual DNA amino acid or nucleotide sequences are much better than brute force distance approaches like DNA hybridization and immunology. Unfortunately, obtaining actual sequences is a slow and costly procedure.

NORMAN I. PLATNICK
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Heaven's Alarm to the World

Halley calculated its return, but others read the comet of 1682 as a warning from on high

by William E. Phipps

Late in the summer of 1682, Edmund Halley of Oxford and Increase Mather of Boston observed and interpreted the movements of the same comet. Halley's cometary theory made him the most famous of English astronomers, while Mather's cometary prognostication helped him become the foremost American-born Puritan. The two views reveal a fundamental dichotomy, the difference between a naturalistic and a supernaturalistic explanation of physical events.

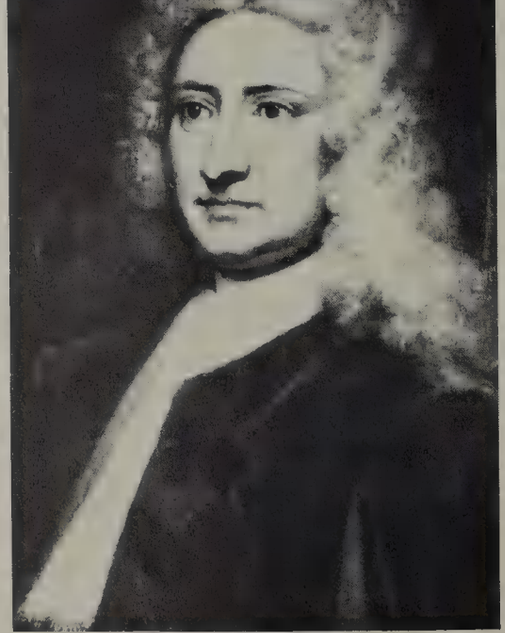
Although Mather defined a comet as "a company of small stars growing into one body" and acknowledged that a comet, like an eclipse, "happens according to the course of nature," he imbued both comet and eclipse with dire meaning, seeing them as "signs of divine anger." This almighty wrath was directed at mankind, specifically toward Mather's parishioners and others in the New England colonies. Had not Harvard University president Chauncy and two local governors died within a year of the 1677 solar eclipse?

From his North Church pulpit, Mather, prompted by the comet of 1680, preached a sermon entitled "Heaven's Alarm to the World." He delivered another address on comets on August 31, 1682, to the congregation he would serve for fifty-nine years. An expanded version of these discourses, which effectively provoked more dread, was published in 1683 with the Greek title *Kometographia*. It was the first book about comets issued in the Western Hemisphere. Mather's rigor on this and other themes—such as "damnable witches" inspired by Satan—secured his prominence in Massachusetts. Accordingly, he was chosen president of Harvard and retained that position for the remainder of the seventeenth century.

A graduate of Harvard, Mather had also studied in Europe. He brought home a traditional Old World explanation of celestial events. For millennia, he claimed, comets had virtually always been seen as "messengers of evil tidings." To defend this harbinger-of-doom theory, Mather cataloged portentous comet appearances "from the beginning of the world unto this present year." The calamities he listed include cultural conflicts and natural catastrophes that chanced to coincide with comet sightings: In 2292 B.C. (exactly 1,656 years after the world was created), a comet announced the Noachian deluge. In A.D. 66 a "blazing star was attended with a terrible persecution in which the apostles Paul and Peter were put to death." A comet augured ill about A.D. 620, when "Mohomet began to diffuse his pestiferous doctrine." The fiery 1066 comet presaged the death of King Harold II and William of Normandy's ascension to the English throne, while another in 1456 was followed by a destructive earthquake in Italy, a great plague, and Turkish military victories over Christians.

When Mather differed with one contemporary astrologer's interpretation of a 1652 comet, he was quick to scorn his rival and set the record straight. He referred to his opponent as "a blind but insolent buzzard" who "undertook to predict strange things from the appearance of this blazing star that never came to pass." The comet actually foretold, Mather disclosed, the "infection" of Quaker ideas in the world.

Greenwich Observatory



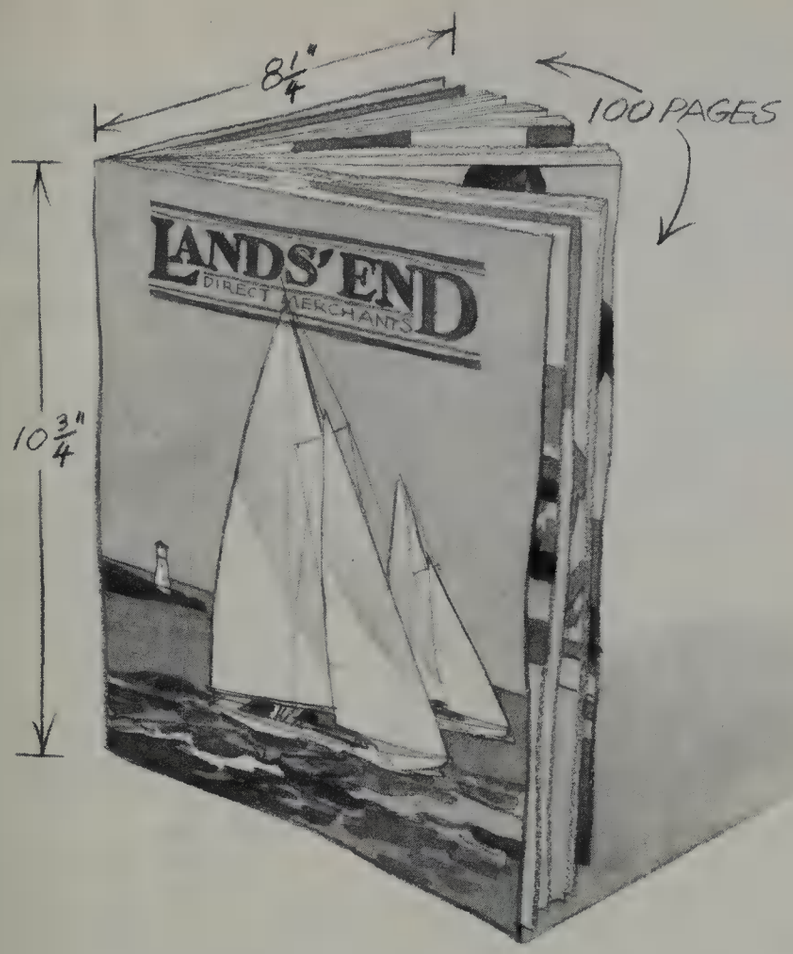
Edmund Halley, 1656–1742

After the 1682 comet, Mather assured his congregation that they could expect "a cold and tedious winter, much snow and consequently great floods; malignant and epidemical diseases."

For Puritans, comets truly signaled "mischiefs and miseries hastening to follow and fall down on the heads of senseless and secure sinners," and they termed this belief "special Providence." By giving comets theological weight and import, American Puritans strengthened the authority of an already powerful clergy. A comet's meaning could be validated only by certified spokesmen of the established Massachusetts religion, not by other astrologers, laymen, or scientists.

Halley was just twenty-five when he seized the only opportunity during his lifetime to observe the comet that now bears his name. He then painstakingly collected all the records made by other comet watchers and was dismayed that most records had been kept by astrologers eager to forecast doom to particular groups of people. Johann Kepler, however, had carefully described nearly identical movements of a 1607 comet, and after unearthing the record of a similar sighting in 1531, Halley wrote his friend Isaac Newton: "I am more and more confirmed that we have seen that comett now three times since ye year 1531." After calculating an elliptical orbit of about seventy-six years in his *Synoptics of Cometary Astronomy*, Halley asserted: "I may venture to foretel that it will return again in the year 1758." When his prediction was fulfilled, Halley was fittingly given the posthumous honor of being a cometary namesake.

Halley and Newton were mutually indebted. Halley recognized Newton's reticence as well as his genius and pressed him to communicate publicly the ideas that Newton had conveyed to him privately. Halley even financed the publication of Newton's *Principia* in 1686. The preface of that landmark book of astrophysics cites "the most acute and universally learned Mr. Edmund Halley"; he was the only person to whom Newton expressed appreciation. By applying the uni-



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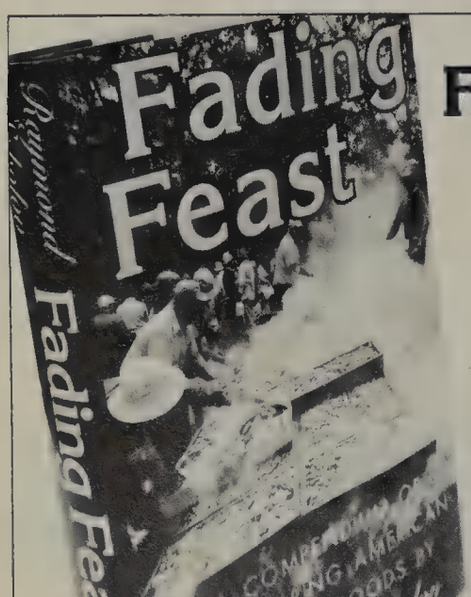

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versal gravitation theory contained in *Principia* and Kepler's laws pertaining to the path and speed of bodies in the solar system, Halley deduced the periodicity of comets. The comet's return in 1758 not only proved Halley correct but also physically confirmed the laws of Kepler and Newton.

Thus Halley's empiricism heralded a modern world of rational inquiry, while Mather's rigidity harkened back to a medieval realm of divine threat and retribution. The cleric "read" Halley's comet of 1456 just as Pope Callistus had in the fifteenth century. The pontiff had appointed a time of prayer and fasting to redirect the divine judgment, so that it would conveniently smite the Turkish Muslims.

Although the popular appeal of astrology is undeniable even today—a Gallup survey discloses that 29 percent of Americans still believe in it—Mather's view was becoming obsolete among men of learning even in his own time. When he claimed competence in divining meanings of celestial phenomena, Mather set himself apart not only from Kepler, Newton, and Halley, who were also religiously oriented men, but also from the mainstream of his professed religion. Disdain for astrology was one important way in which biblical religions diverged from other ancient religions. The dominant religions of Western culture regard astral fatalism as incompatible with moral freedom. Although Mather thought of himself as a staunch Calvinist, a century earlier, John Calvin himself had rejected fatalism and advised theologians not to seek answers to astronomical questions in religious texts.

As surely as his predecessors believed the earth to be the core of the universe, Mather espoused a largely human-centered view of natural phenomena. Comets and eclipses were created, he believed, primarily to impact earthlings. Celestial sights were not wondrous visions granted to God's people on earth but threats, signs of paternal anger, and tools for enforcing authority. Halley saw comets as manifestations of gaseous elements, indifferent to stargazers, astronomers and astrologers alike, but subject to laws discernible by humans. His outlook stands in bold relief to astrology, which perennially finds human prejudices reflected in the heavens and human futures fated by their configuration. Halley viewed the A.D. 66, 1066 and 1456 comet apparitions, to which Mather referred, as unportentous earlier orbits of the same comet.

William E. Phipps is professor of religion and philosophy at Davis and Elkins College, Elkins, West Virginia.

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To Be a Platypus

Although it com'st in such a questionable shape, this animal, above all, is true to itself

by Stephen Jay Gould

Long ago, garrulous old Polonius exalted brevity as the soul of wit, but later technology, rather than sweet reason, won his day and established verbal condensation as a form of art in itself. The telegram, sent for cash on the line and by the word, made brevity both elegant and economical—and the word *telegraphic* entered our language for a style that conveys bare essentials and nothing else.

The prize for transmitting most meaning with least verbosity must surely go to the British officer who subdued the Indian province of Sind and announced his triumph, via telegram to his superiors in London, with the minimal but fully adequate "*Peccavi.*" (This tale, in its own telegraphic way, speaks volumes about the social order and education of imperial Britain. In an age when all gentlemen studied Latin, and could scarcely rise in government service without a boost from the old boys of similar background in appropriate public schools, the officer never doubted that his superiors would remember the first person past tense of the verb *peccare*—and would properly translate his message and pun: I have sinned.)

The most famous telegram from my profession did not quite reach this admirable minimum, but it must receive honorable mention for conveying a great deal in few words. In 1884 (I meant to write this column last year to catch the centenary), W.H. Caldwell, a young Cambridge biologist, sent his celebrated telegram from Australia to a triumphant reading at the Annual Meeting of the British Association in Montreal. Caldwell wired: "Monotremes oviparous, ovum meroblastic."

This message may lack the ring of *peccavi* and might be viewed by the uninitiated as pure mumbo jumbo. But all professional biologists could make the translation and recognize that Caldwell had solved a particularly stubborn and vexatious problem of natural history. In essence, his telegram said: the duckbilled platypus (and its relative, the spiny echidna) lays eggs.

(Each word of Caldwell's telegram needs some explication. Oviparous animals lay eggs, while viviparous creatures give birth to live young; ovoviviparous organisms form eggs within their bodies, and young hatch inside their mothers. Sorry for the jargon so early in the column, but these distinctions become important later on. Monotremes are that most enigmatic group of mammals from the Australian region—including the spiny echidna, actually two separate genera of anteaters, and the duckbilled platypus, an inhabitant of streams and creeks. An ovum is an egg cell, and meroblastic refers to a mode of cleavage, or initial division into embryonic cells, after fertilization. Yolk, the egg's food supply, accumulates at one end of the ovum, called the vegetal pole. Cleavage begins at the other end, called the animal pole. If the egg is very yolky, the cleavage plane cannot penetrate and divide the vegetal end. Such an egg shows incomplete, or meroblastic, cleavage—division into discrete cells at the animal pole but little or no separation at the yolky end. Egg-laying land vertebrates, reptiles and birds, tend to produce yolky ova with meroblastic cleavage, while most mammals show complete, or holoblastic, cleavage. Therefore, in adding "ovum meroblastic" to "monotremes oviparous," Caldwell emphasized the reptilian character of these paradoxical mammals—not only do they lay eggs but the eggs are typically reptilian in their yolkiness.)

The platypus surely wins first prize in anybody's contest to identify the most curious mammal. Harry Burrell, author of the classic volume on this paradox (*The Platypus: Its Discovery, Position, Form and Characteristics, Habits and Life History,* Sydney, Angus and Robertson, 1927) wrote: "Every writer upon the platypus begins with an expression of wonder. Never was there such a disconcerting animal!" (I guess I just broke tradition by starting with the sublime *Hamlet.*)

The platypus sports an unbeatable combination for strangeness: first, an odd habitat with curiously adapted form to match; second, the real reason for its special place in zoological history—its enigmatic mélange of reptilian (or birdlike), with obvious mammalian, characters. Ironically, the feature that first suggested premammalian affinity—the "duckbill" itself—supports no such meaning. The platypus's muzzle (the main theme of this column) is a purely mammalian adaptation to feeding in fresh waters, not a throwback to ancestral form—although the duckbill's formal name embodies this false interpretation: *Ornithorhynchus anatinus* (or the ducklike bird snout).

Chinese taxidermists had long fooled (and defrauded) European mariners with the heads and trunks of monkeys stitched to the hind parts of fish—one prominent source for the persistence of mermaid legends. In this context, one can scarcely blame George Shaw for his caution in first describing the platypus (1799):

> Of all the Mammalia yet known it seems the most extraordinary in its conformation, exhibiting the perfect resemblance of the beak of a Duck engrafted on the head of a quadruped. So accurate is the similitude, that, at first view, it naturally excites the idea of some deceptive preparation.

But Shaw could find no stitches, and the skeleton was surely discrete and of one functional piece (the premaxillary bones of the upper jaw extend into the bill and

rovide its major support—no one had rafted a duck onto a beaver). Shaw concluded:

)n a subject so extraordinary as the resent, a degree of scepticism is not only ardonable but laudable; and I ought perhaps to acknowledge that I almost doubt ne testimony of my own eyes with respect o the structure of this animal's beak; yet nust confess that I can perceive no appearnce of any deceptive preparation . . . nor an the most accurate examination of exert anatomists discover any deception.

But if the bill had been a come-on, the ear end provided numerous, and legitiate, reasons for amazement. The platyus sported only one opening, the cloaca, or all excretory and reproductive busiess (as in reptiles, but not most mamals, with their multiplicity of orifices for irth and various forms of excretion. Monotremata, or one-holed, the technical ame for the platypus and allied echidna, onors this unmammalian feature).

Internally, the puzzle only increased. The oviducts did not unite into a uterus, ut extended separately into the cloacal ube. Moreover, as in birds, the right vary had become rudimentary, and all gg cells formed in the left ovary. This onfiguration obviously led to a most troubling hypothesis for biologists committed, s most were in these pre-Darwinian days, o the division of nature into unambiguus, static categories: no uterus, no interal space to form a placenta, a reproductive tract reptilian in form. All this uggested the unthinkable for a mamnal—birth from eggs. The neighboring narsupials, with their pouches and tiny joys, had already compromised the noble ame of mammal. Would Australia also ield the ultimate embarrassment of fur rom eggs?

As anatomists studied this creature

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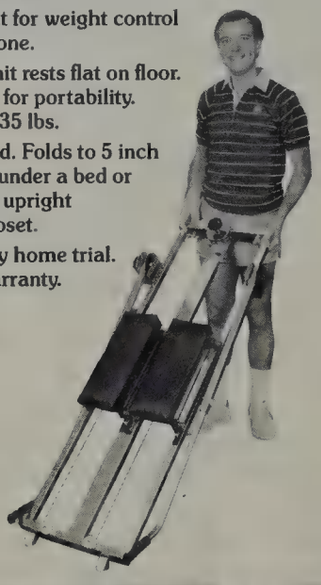

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early in the nineteenth century, the mystery only deepened. The platypus looked like a perfectly good mammal in all "standard" nonreproductive traits. It sported a full coat of hair and the defining anatomical signature of mammals—one bone, the dentary, in its lower jaw and three, the hammer, anvil, and stirrup, in its middle ear. (Reptiles have several jawbones and only one ear bone. Two reptilian jawbones became the hammer and anvil of the mammalian ear.) But its premammalian characters extended beyond the reproductive system. In particular, the platypus grew an interclavicle bone in its shoulder girdle—a feature of reptiles but shared by no placental mammal.

What could this curious mélange be, beyond a divine test of faith and patience? Debate centered on modes of reproduction, for eggs had not yet been found and Caldwell's telegram lay half a century in the future. All three possibilities boasted their vociferous and celebrated defenders—for no great biologist could avoid such a fascinating creature and all leaders of natural history entered the fray. Meckel, the great German anatomist, and his French colleague Blainville predicted viviparity, argued that eggs would never be found, and accommodated the monotremes among ordinary mammals. E. Home, who first described the platypus in detail (1802), and the renowned English anatomist Richard Owen chose the middle pathway of ovoviviparity and argued that failure to find eggs indicated their dissolution within the female's body. But the early French evolutionists, Lamarck and Etienne Geoffroy Saint-Hilaire, insisted that anatomy could not lie and that the platypus must be oviparous. Eggs, they argued, would eventually be found.

Geoffroy, by the way, coined the name *monotreme* in an interesting publication that reveals as much about French social history as *peccavi* indicated for imperial Britain. This issue of the *Bulletin des sciences* is labeled *Thermidor, an 11 de la République*. With revolutionary fervor at its height, France broke all ties with the old order and started counting again from year one (1793). They also redivided the year into twelve equal months, with a few days left over for annual rejoicing, and renamed the months to honor the weather rather than old gods and emperors. Thus, Geoffroy named the monotremes in a summer month (Thermidor) during the eleventh year (1803) of the Republic.

Just one incident in the pre-Caldwell wars will indicate the intensity of nineteenth-century debate about platypuses and the relief at Caldwell's resolution. When the great naturalists delineated their positions and defined the battleground, mammary glands had not been found in the female platypus—an apparent argument for those, like Geoffroy, who were trying to distance monotremes as far as possible from mammals. Then, in 1824, Meckel discovered mammary glands. But since platypuses never do anything by the book, these glands were peculiar enough to spur more debate rather than conciliation. The glands were enormous, extending nearly from the forelegs to the hind limbs—and they led to no common opening, for no nipples could be found. (We now know that the female excretes milk through numerous pores onto a portion of her ventral surface, where the baby platypus laps it up.) Geoffroy, committed to oviparity and unwilling to admit anything like a mammalian upbringing, counterattacked. Meckel's glands, he argued, were not mammary but homologs of the odiferous flank glands of shrews, secreting substances for attraction of mates. When Meckel then expressed a milky substance from the mammary gland, Geoffroy admitted that the secretion must be food of some sort, but not milk. The glands, he now argued, are not mammary but a special feature of monotremes, used to secrete thin strands of mucus that thicken in water to provide food for young hatched from the undiscovered eggs.

Owen then counterattacked to support Meckel for three reasons: the glands are largest shortly after the inferred time of birth (though Geoffroy expected the same for mucus used in feeding); the female echidna, living in sand and unable to thicken mucus in water, possesses glands of the same form. Finally, Owen suspended the secretion in alcohol and obtained globules, like milk, not angular fragments, like mucus (an interesting commentary upon the rudimentary state of chemical analysis during the 1830s).

Geoffroy held firm—both to oviparity (correctly) and to the special status of feeding glands (incorrectly, for they are indeed mammary). In 1822, Geoffroy formally established the Monotremata as a fifth class of vertebrates, ranking equally with fishes, reptiles (then including amphibians), birds, and mammals. We may view Geoffroy as stubborn and we certainly now regard the monotremes as mammals, however peculiar—but he presents a cogent and perceptive argument well worth our attention. Don't shoehorn monotremes into the class Mammalia to make everything neat and foreclose discussion, he pleads. Taxonomies are guides to action, not passive devices for ordering. Leave monotremes separate and in uncomfortable limbo—"which suggests the necessity of further examination [and] is far better than an assimilation to normality, founded on strained and mistaken relations, which invites indolence to believe and slumber" (letter to the Zoological Society of London, 1833).

Geoffroy also kept the flame of oviparity alive, arguing that the cloaca and reproductive tract bore no other interpretation: "Such as the organ is, such must be its function; the sexual apparatus of an oviparous animal can produce nothing but an egg." So Caldwell arrived in Australia in September 1883—and finally resolved the great debate, eighty years after its inception.

Caldwell, though barely a graduate, proceeded in the grand imperial style (he soon disappeared from biological view and became a successful businessman in Scotland). He employed 150 aboriginals and collected nearly 1,400 echidnas—quite a hecatomb for monotreme biology. On the subject of social insights, this time quite uncomfortable, Caldwell described his colonial style of collecting:

> The blacks were paid half-a-crown for every female, but the price of flour, tea, and sugar, which I sold to them, rose with the supply of Echidna. The half-crowns were therefore, always just sufficient to buy food enough to keep the lazy blacks hungry.

It was, of course, often done—but rarely said so boldly and without apology. In any case, Caldwell eventually found the eggs of the platypus (usually laid two at a time and easily overlooked at their small size of less than an inch in length).

Caldwell solved a specific mystery that had plagued zoology for nearly a century but he only intensified the general problem. He had proved irrevocably that the platypus is a mélange, not available for unambiguous placement into any major group of vertebrates. Geoffroy had been right about the eggs; Meckel about the mammary glands.

The platypus has always suffered from false expectations based on human fables. (This column discusses the two stages of this false hoping, and then tries to rescue the poor platypus in its own terms.) During the half-century between its discovery and Darwin's *Origin of Species*, the platypus endured endless attempts to deny or mitigate its true melange of characters associated with different groups of vertebrates. Nature needed clean categories established by divine wisdom. An animal could not both lay eggs and feed its young with milk from mammary glands. So Geoffroy insisted upon eggs and no milk; Meckel upon milk and live birth.

Caldwell's discovery coincided with the enty-fifth anniversary of Darwin's *Ori- n.* By this time, evolution had made the ea of intermediacy (and mélanges of iaracters) acceptable, if not positively in- iguing. Yet, freed of one burden, the atypus assumed another—this time im- osed by evolution, the very idea that had st liberated this poor creature from un- ongenial shoving into rigid categories. he platypus, in short, shouldered (with s interclavicle bone) the burden of prim- iveness. It would be a mammal, to be ire—but an amoeba among the gods; a wdry, pitiable little fellow weighted own with the reptilian mark of Cain.

Caldwell dispatched his epitome a cen- ıry ago, but the platypus has never es- aped. I have spent the last week as a early full-time reader of platypusology. Vith a few welcome exceptions (mostly mong Australian biologists who know the reature intimately), nearly every article lentifies something central about the latypus as undeveloped or inefficient rel- tive to placental mammals—as if the un- oubted presence of premammalian char- cters condemns each feature of the platy- us to an unfinished, blundering state.

Before I refute the myth of primitive- ess for the platypus in particular, I hould discuss the general fallacy that quates early with inefficient and still un- erlies so much of our failure to under- tand evolution properly. The theme has irculated through these columns for ears—ladders and bushes. But I try to rovide a new twist here—the basic dis- nction between *early branching* and *un- eveloped,* or *inefficient, structure.*

If evolution were a ladder toward rogress, with reptiles on a rung below ammals, then I suppose that eggs and an nterclavicle would identify platypuses as ntrinsically wanting. But the Old Testa- ent author of Proverbs, though speaking f wisdom rather than evolution, provided he proper metaphor, *etz chayim:* she is a *ree of life* to them who take hold upon er. Evolution proceeds by branching, and ot (usually) by wholesale transformation nd replacement. Although a lineage of eptiles did evolve into mammals, reptiles emain with us in all their glorious abun- ance of snakes, lizards, turtles, and croc- diles. Reptiles are doing just fine in their wn way.

The presence of premammalian charac- ers in platypuses does not brand them as nferior or inefficient. But these charac- ers do convey a different and interesting nessage. They do signify an early branch- ng of monotreme ancestors from the ineage leading to placental mammals. This lineage did not lose its reptilian char-

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acters all at once, but in the halting and piecemeal fashion so characteristic of evolutionary trends. A branch that split from this central lineage after the defining features of mammals had evolved (hair and an earful of previous jawbones, for example) might retain other premammalian characters (birth from eggs and an interclavicle) as a sign of early derivation, not a mark of backwardness.

The premammalian characters of the platypuses only identify the antiquity of their lineage as a separate branch of the mammalian tree. If anything, this very antiquity might give the platypus more scope (that is, more time) to become what it really is, in opposition to the myth of primitivity: a superbly well-designed creature for a particular, and unusual, mode of life. The platypus is an elegant solution for mammalian life in streams—not a primitive relic of a bygone world. Old does not mean hidebound in a Darwinian world.

Once we shuck the false expectation of primitiveness, we can view the platypus more fruitfully as a bundle of adaptations. Within this appropriate theme of *good* design, we must make one further distinction between shared adaptations of all mammals and particular inventions of platypuses. The first category includes a coat of fur well adapted for protecting platypuses in the (often) cold water of their streams (the waterproof hair even traps a layer of air next to the skin, thus providing additional insulation). As further protection in cold water and on the same theme of inherited features, platypuses can regulate their body temperatures as well as most "higher" mammals, although the assumption of primitivity stalled the discovery of this capacity until 1973—before that, most biologists had argued that platypus temperatures plummeted in cold waters, requiring frequent returns to the burrow for warming up. (My information on the ecology of modern platypuses comes primarily from Tom Grant's excellent book, *The Platypus,* New South Wales University Press, 1984, and from conversations with Frank Carrick in Brisbane. Grant and Carrick are Australia's leading professional students of platypuses, and I thank them for their time and care.)

These features, shared by passive inheritance with most other animals, certainly benefit the platypus, but they provide no argument for my theme of direct adaptation—the replacement of putative primitivity by a view of the platypus as actively evolving in its own interest. Many other features, however, including nearly everything that makes the platypus so distinctive, fall within the second category of special invention.

Platypuses are relatively small mammals (the largest known weighed just over five pounds and barely exceeded two feet from tip to tail). They construct burrows in the banks of creeks and rivers: long (up to sixty feet) for nesting; shorter for daily use. They spend most of their life in the water, searching for food (primarily insect larvae and other small invertebrates) by probing into bottom sediments with their bills.

The special adaptations of platypuses have fitted them in a subtle and intricate way for aquatic life. The streamlined body moves easily through water. The large, webbed forefeet propel the animal forward by alternate kicks, while the tail and partially webbed rear feet act as rudders and steering devices (in digging a burrow, the platypus anchors with its rear feet and excavates with its forelimbs). The bill works as a feeding structure par excellence, as I shall describe in a moment. Other features undoubtedly serve in the great Darwinian game of courtship, reproduction, and rearing—but we know rather little about this vital aspect of platypus life. As an example, males bear a sharp, hollow spur on their ankles, attached by a duct to a poison gland in their thighs. These spurs, presumably used in combat with competing males, grow large during the breeding season. In captivity, males have killed others with poison from their spurs, and many platypuses, both male and female, sport distinctive punctures when captured in the wild.

Yet even this long and impressive list of special adaptations has been commonly misrepresented as yet another aspect (or spinoff) of pervasive primitiveness. Burrell, in his classic volume (1927), actually argued that platypuses develop such complex adaptations because simple creatures can't rely upon the flexibility of intelligence and must develop special structures for each required action. Burrell wrote:

> Man . . . has escaped the need for specialization because his evolution has been projected outside himself into an evolution of tools and weapons. Other animals in need of tools and weapons must evolve them from their own bodily parts; we therefore frequently find a specialized adaptation to environmental needs grafted on to primitive simplicity of structure.

You can't win in such a world. You are either primitive prima facie or specialized as a result of lurking and implicit simplicity! From such a Catch-22, platypuses can only be rescued by new concepts, not additional observations.

As a supreme irony, and ultimate defense of adaptation versus ineptitude, the structure that built the myth of primitivity—the misnamed duckbill itself—represents the platypus's finest special invention. The platypus bill is not a homolog of any feature in birds. It is a novel structure uniquely evolved by monotremes (the echidna carries a different version as its long and pointed snout). The bill is not simply a hard, inert horny structure. Soft skin covers the firm substrate, and this skin houses a remarkable array of sensory organs. In fact, and strange to tell, the platypus, when under water, shuts down all its other sensory systems and relies entirely upon its bill to locate obstacles and food. A flap of skin covers the tiny eyes and nonpinnate ears when a platypus dives, while a pair of valves closes off the nostrils under water.

E. Home, in the first monograph on platypus anatomy (1802), made an astute observation that correctly identified the bill as a complex and vital sensory organ. He dissected the cranial nerves and found almost rudimentary olfactory and optic members but a remarkably developed trigeminal, carrying information from the face to the brain. With great insight Home compared the platypus bill to a human hand in function and subtlety (Home never saw a live platypus and worked only by inference from anatomy). He wrote:

> The olfactory nerves are small and so are the optic nerves; but the fifth pair which supplies the muscles of the face are uncommonly large. We should be led from this circumstance to believe, that the sensibility of the different parts of the bill is very great, and therefore it answers to the purpose of a hand, and is capable of nice discrimination in its feeling.

Then, in the same year as Caldwell discovered eggs, the English biologist E.E. Poulton found the primary sensory organ of the bill. He located numerous columns of epithelial cells, each underlain by a complex of neural transmitters. He called them "push rods," arguing by analogy with electrical bells that a sensory stimulus (a current of water or an object in bottom sediments) would depress the column and ignite the neural spark.

A set of elegant experiments in modern neurophysiology by R.C. Bohringer and M.J. Rowe (*Journal of Comparative Neurology,* vol. 177, 1977, and *Australian Mammalogy,* vol. 4, 1981) can only increase our appreciation for the finely tuned adaptation of the platypus bill. They found Poulton's rods over the bill's entire surface, but four to six times more densely packed at the anterior border of the upper bill, where platypuses must first encounter obstacles and food items. They noted different kinds of nerve recepto

nder the rods, suggesting that platypuses
n distinguish varying kinds of signals
erhaps static versus moving components
· live versus dead food). Although indi-
dual rods may not provide sufficient in-
rmation for tracing the direction of a
imulus, each rod maps to a definite loca-
on on the brain, strongly implying that
ie sequence of activation among an array
f rods permits the platypus to identify the
ze and location of objects.

Neurophysiologists can locate areas of
ie brain responsible for activating defi-
ite parts of the body and draw a "map" of
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eriments proceed from either direction.
)ne either stimulates a body part and
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ave no finer demonstrations of evolution-
ry adaptation than numerous brain maps
hat record the importance of specially de-
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arged areas of representation upon the
ortex. Thus, a raccoon's brain map dis-
lays an enormous domain for its fore-
aws, a pig's for its snout, a spider mon-
ey's for its tail. Bohringer and Rowe have
dded the platypus to this informative ar-
ay. A map of the platypus's brain is
nostly bill.

We have come a long way from the first
rominent evolutionary interpretation
ver presented for the platypus bill. In
844, in the major pre-Darwinian defense
f evolution written in English, Robert
Chambers tried to derive a mammal from
bird in two great leaps, via the interme-
liate link of a duckbilled platypus. One
tep, Chambers wrote,

vould suffice in a goose to give its progeny
he body of a rat, and produce the orni-
horhynchus, or might give the progeny of
n ornithorhynchus the mouth and feet of a
rue rodent, and thus complete at two
tages the passage from the aves to the
nammalia.

The platypus, having suffered such
lings and arrows of outrageous fortune in
mposed degradation by human hands,
as cast its arms (and its bill) against a sea
f troubles and vindicated itself. The
vhips and scorns of time shall heal. The
ppressor's wrong, the proud man's con-
umely have been reversed by modern
tudies—enterprises of great pith and mo-
nent. The platypus is one honey of an ad-
ptation.

*Stephen Jay Gould teaches biology, geol-
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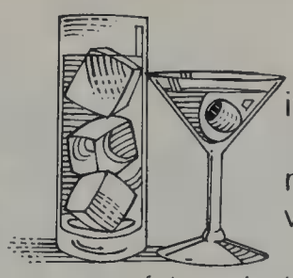

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Where's the Gas?

Recent observations on elliptical galaxies contradict previous basic beliefs

by Stephen P. Maran

Elliptical galaxies include the largest star systems yet discovered, as well as many small ones. They are one of the four principal types of galaxies—the so-called island universes of billions or perhaps trillions of stars. (The other three types are spirals, spheroidals, and irregulars.)

Unlike our Milky Way and the Andromeda, which are spiral galaxies, ellipticals have no spiral arms and few or no bright nebulae (interstellar clouds of hot gas and dust) or bright young blue stars. Because ellipticals seemed to contain little, if any, interstellar gas and dust—the basic materials from which stars are born—astronomers dismissed them as dead galaxies in which star formation ended billions of years ago. Also unlike the spiral galaxies, the ellipticals do not have a disk—a flat system of stars and nebulae. On photographic maps they are shaped like ellipses and their brightness decreases smoothly from the center to the outskirts. "The star distribution in an elliptical galaxy is uncannily smooth," remarked British cosmologist Fred Hoyle.

Elliptical galaxies seem to have an enormous range of sizes. Some, like M32, a dwarf companion of the great Andromeda spiral, are tiny, with diameters of 10,000 light-years or less; others, like M87 in Virgo, are giants, some exceeding 150,000 light-years in size. (A light-year is the distance traversed at the speed of light in a vacuum over an interval of one year. One light-year equals about 5.8 trillion miles.) You can see M32 in most astronomy books, as a minor object in photographs of Andromeda; M87 is pictured about as often, usually to show the spectacular blue jet that emanates from its center.

Other than the contrast in form, the most pronounced difference between elliptical and spiral galaxies is the general lack of gas, dust, and hot young stars in ellipticals. At least, that's what astronomers believed until recently. For example, observations made in February 1974 with the 140-foot radio telescope at the National Radio Astronomy Observatory in Green Bank, West Virginia, showed that neutral hydrogen, a gas in which each atom consists of one proton and one electron, makes up no more than one-tenth of one percent of the mass of elliptical galaxies, although it is a principal constituent of the interstellar matter in the Milky Way. The survey scientists, John S. Gallagher, Sandra M. Faber, and Bruce Balick, concluded that the severe deficiency of neutral hydrogen in elliptical galaxies "is consistent with other observed features," including the lack of dust lanes (the dark streaks that cross the disks of spiral galaxies) and bright nebulae, all indicating "that little interstellar matter is present." In spiral galaxies, on the other hand, clouds of gas and dust and groups of hot young stars dot the spiral arms and make them readily apparent. Since new stars form in the interstellar clouds of the Milky Way, astronomers concluded that elliptical galaxies were no longer forming stars.

In 1976, Faber and Gallagher again explored the issue of the missing interstellar gas. They wanted to see if the gas was somehow hidden from view or if it had been removed from the galaxies. On balance, they concluded, the gas had been removed, probably by a galactic wind, a phenomenon whose existence was proposed in 1971 by two California astrophysicists, William G. Mathews and James C. Baker.

Earlier investigators believed that the gas and dust in elliptical galaxies had been used up in the formation of stars. However, as we study the stars in the Milky Way, we find that they tend to shed gas in the form of winds or puffs from explo sions; gas is also shed during the expulsion of the stars' outer layers, producing so called planetary nebulae, such as the Ring nebula in the constellation Lyra. Our own sun produces the solar wind, a constant outpouring of electrified gas; and red gi ant stars have much stronger winds, which blow huge amounts of gas out into space Dust particles also seem to form in the cooling gases expelled from red giant stars. Thus, in the Milky Way, gas and dust beget stars that shed more gas and dust, which beget more stars.

According to Mathews and Baker, the total amount of gas released into interstellar space in a large elliptical galaxy through winds from red giant stars, the formation of planetary nebulae, and other causes, must amount to between one-tenth the mass of our sun to a full solar mass per year. At that rate, a billion or more solar masses of interstellar gas should have collected in the large elliptical galaxies since the formation of all galaxies early in the history of the universe. However, even in 1971, before the Gallagher survey, scientists knew that large amounts of gas were not present in elliptical galaxies. Mathews and Baker explained this discrepancy by proposing that "gas ejected from stars in elliptical galaxies is heated by supernova explosions and produces outward-flowing galactic winds."

In past years, whenever a study revealed the presence of some gas or dust or even evidence for young stars in an elliptical galaxy, the galaxy in question was dismissed as an oddball, an exception that proved the rule that ellipticals have no new stars because they lack the raw materials needed to make them. Thus, the jet ejection in M87, though gaseous, was re

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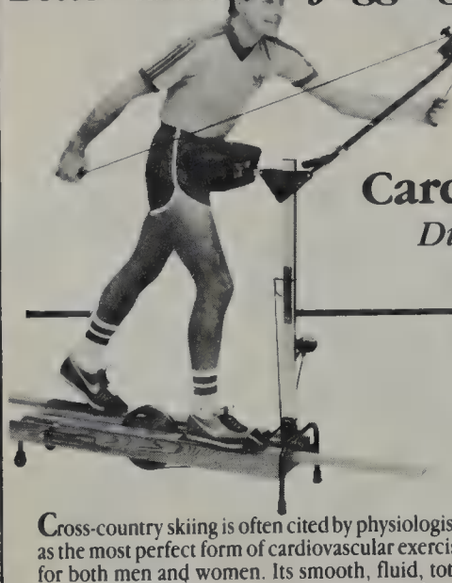

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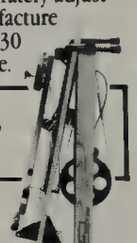

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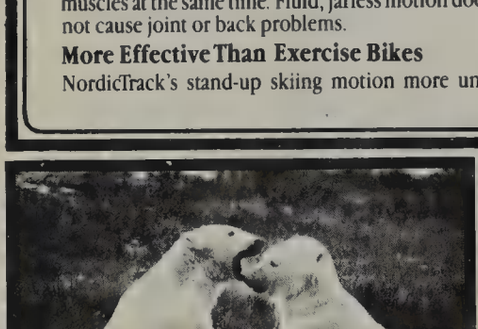

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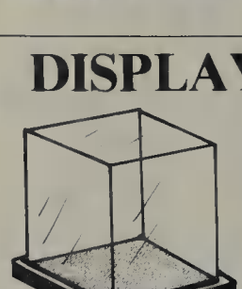

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garded as a symptom of a rare phenomenon at the center of the galaxy, perhaps involving a giant black hole.

Recently, new evidence has shown that these old ideas are wrong. Dust lanes, for example, are caused by dust clouds that cut off light from the stars beyond. Even though a few dust lanes were detected in elliptical galaxies years ago, they were thought to be extreme rarities. Last year, however, two astronomers from Munich reported at a French conference on galaxies that dust lanes are actually common in nearby elliptical galaxies. Recent photographs from a Schmidt telescope in Chile, they found, show traces of dust lanes in these galaxies. Since it is impossible to detect dust lanes on current telescopic photographs of more distant ellipticals, we don't know whether they are present in these galaxies. But once NASA's Hubble Space Telescope is launched in 1986, we will know more. The telescope's photographs will be at least ten times sharper than those taken by today's ground-based telescopes.

The observations that, above all others, have led to a new understanding of elliptical galaxies were made with Einstein, a satellite observatory launched in 1978 that provided the first fairly sharp X-ray images of galaxies. At first, astronomers who studied the Einstein images concentrated on the properties of X-ray emission from large clusters of galaxies. They found that those emissions often contain an intracluster medium of very hot gas (about 180 million degrees Fahrenheit) which pervades the space between member galaxies of a cluster (see "Clusters of Galaxies," *Natural History*, February 1983). In some cases, the intracluster medium seems to be concentrated toward the center of a cluster, suggesting that the gas is cooling and settling there, a phenomenon known as a cooling flow. In other clusters, elliptical galaxies were found to glow from hot gas of their own, which shines in X-rays because, although it is very thin, it is also very hot. The Einstein-detected gas is so hot that it is fully ionized; in other words, its constituent atoms have each lost at least one electron. Most of the gas is hydrogen, and since hydrogen atoms have only one electron to begin with, which they lose upon ionization, the gas is not neutral. This hydrogen was not detectable by the radio observations employed in the 1974 Gallagher survey; that survey only detected radio emission from *neutral* hydrogen.

The discovery that elliptical galaxies in some clusters contain very hot, ionized hydrogen had unclear implications for another question: whether elliptical galaxies

general contain much gas. The presence f hot gas in the cluster members might, or example, be related to the properties of ie cluster, including its intracluster me- ium.

Last year, three astrophysicists from Cambridge University published a con- incing study of Einstein observations of olated elliptical galaxies (those not lo- ated in clusters). They found that iso- ted ellipticals glow in X-rays just as ome elliptical galaxies in clusters glow. The gas, at a temperature of perhaps 90 illion degrees Fahrenheit, is fully ion- zed, just like the even hotter intracluster edium mentioned above.

Could the hot gas observed in X-rays by he British investigators be the galactic vind postulated by Mathews and Baker? Gas heated by supernova explosions night well be very hot. However, if the ob- erved gas were the putative galactic vind, continuously escaping from the par- nt elliptical galaxy, then it would have to e replenished by the release of about ten olar masses of gas per year from red gi- nts and other stars in the galaxy. And this quantity is at least ten times larger than what the star population of a large ellipti- al galaxy can provide. In other words, the X-ray emission requires much more gas than can remain in an elliptical galaxy constantly subject to an outflowing galactic wind.

If the hot gas in isolated elliptical galaxies observed by the Einstein satellite is not escaping as a wind, then it must be cooling as it remains around the galaxy. In that case, some of the gas is probably sinking toward the center of its parent galaxy and becoming denser as it cools. As it thickens, the gas should condense to form new stars. That would explain why observations with visible light and radio telescopes show very little cool gas. Hot gas is observed in X-rays; cool gas, we think, is used up in making stars.

If new stars are forming in elliptical galaxies, why don't we find groups of bright, hot young stars in them, as we do in the Milky Way and other spiral and irregular galaxies? Although the hot young stars are very massive compared to the sun, they are rare. Most stars, in fact, are less massive than the sun. The more massive a normal star is, the brighter it shines as a result of nuclear reactions in its interior. In most galaxies in which star formation has been studied, we cannot pick out less conspicuous individuals—the medium- and low-mass stars comparable in size to our sun. If we could pick them out, we would find it difficult to say whether they were very young, since stars like the sun are changing very slowly, whereas massive stars run through their lives in only a few million years. Newly formed stars in elliptical galaxies cannot be massive, since they would be observed but are not. Instead, they may be the size of the sun or even smaller.

The Einstein evidence demonstrates that elliptical galaxies contain hot gas, readily detectable only with X-ray telescopes. As the gas cools, it is probably consumed in the formation of new stars. Under the circumstances in which gas cools and condenses in ellipticals, however, the kind of massive, young stars that we could actually hope to detect apparently form rarely, if ever.

New stars of modest mass may well be forming in elliptical galaxies, but at present no known technique can detect and identify them. Accordingly, elliptical galaxies may be evolving star systems after all—not mere fossil remnants of an ancient epoch of star birth.

Stephen P. Maran is a senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Space Flight Center in Greenbelt, Maryland. The opinions expressed here are his own.

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When Three Equals Four

by Thomas D. Nicholson

Here's a puzzle: How can three planets give us two bright objects in the evening and two bright objects in the morning? Easy—when one of them is Jupiter and it's just past opposition. In August, we see it both after sunset and before sunrise. While Saturn is in the southwest in the early evening, Jupiter is in the southeast. Saturn sets about three and a half hours after the sun, but Jupiter rises higher, appearing at its highest in the south about midnight. Continuing across the sky in the morning hours, it eventually fades into the twilight of the west before setting shortly before sunrise. Meantime, Venus rises several hours after midnight and appears high and bright in the southeast before the sun comes up.

Jupiter and Venus are easy to recognize as they far outshine any star in the night sky. Jupiter will be the brightest "star" that you will see on August nights until Venus rises in the early morning. Venus, the third brightest celestial object, is more than two and a half times more brilliant than Jupiter and will dominate the southeastern sky for several hours before sunup. Saturn, although not as prominent as Jupiter or Venus, can be easily sighted if you can recognize Scorpius with its hooked tail and the bright reddish star Antares marking the position of its heart. Saturn is in front (to the west) of the Scorpion, nestled between two dimmer stars that were once the Scorpion's claws but are now part of Libra. On the 22d, the moon will pass just below (to the south of) Saturn, making the planet easy to locate. If you have a small telescope with at least 40 power, you will be able to glimpse Saturn's beautiful ring system. At the beginning of August, Mercury will be lost in the sun's glare, but by month's end it may be viewed low in the east just before sunrise.

The following events are given in eastern standard time unless otherwise indicated.

August 1: The moon is one day past full, riding the border between Capricornus and Aquarius across the sky. The bright object within its glow is Jupiter, to its west.

August 2–7: The waning gibbous moon works its way east through the autumn stars, rising with them in the late evening and continually growing thinner and dimmer. Look for the four stars in the Square of Pegasus above the moon this weekend.

August 4: Jupiter has been slowly edging away from the morning and into the evening, and today it makes the jump. Opposite the sun at about 7:00 A.M., it rises slightly before sundown, making it an evening star. But it still has a healthy presence in the dawn.

August 7: Apogee moon (farthest from the earth) is in Aries, marked by the constellation's two well-known stars, Hamal and Sheratan, above it. The moon left the First Point of Aries (the vernal equinox) behind several nights ago.

August 8: Last-quarter moon, still in Aries, is at 1:29 P.M.

August 9–11: The morning moon, a shrinking crescent, moves through Taurus, a constellation we will see in the evening this winter.

August 10: Mercury is at inferior conjunction (between the earth and sun), entering the morning sky.

August 11–13: These are the best mornings for the old faithful of the meteor showers, the Perseids. Expect thirty to fifty meteors per hour (maximum in the postmidnight hours on the night of the 11th into the morning of the 12th, many very bright). Best time to look is from 1:00 to 3:00 A.M.; pick a place where you can comfortably see as much of the sky as possible. The dim light of the waning crescent moon should be no bother.

August 13: Watch the crescent moon crawl away from Venus in the dawn sky. It slipped past the planet about moonrise.

August 16: New moon occurs in Leo at 5:06 A.M.

August 18: You should see the young crescent moon in the southwest after sundown, just above the summer solstice.

August 19: Tonight's crescent moon, near Spica in Virgo, is at perigee (nearest the earth).

August 20: Mercury ends its retrograde slide between the earth and sun. It resumes direct (easterly) motion today.

August 22: The moon is about to pass into Scorpius when it reaches first-quarter phase at 11:26 P.M. The star to its right is Saturn, in Libra.

August 23: The reddish star near tonight's moon is Antares, in the Scorpion. You should easily be able to trace the curved tail of Scorpius below and to the left of the moon.

August 25: The gibbous moon shouldn't be too bright for finding the teapot-shaped group of stars that marks Sagittarius. The peak of the teapot "lid" is just above the moon, the spout is to the right, and the handle to the left.

August 27–28: As it slips east through Capricornus, the gibbous moon passes below Jupiter. The planet is to the moon's left on the 27th, to its right on the 28th.

August 28: Mercury may be viewed in the morning sky of late August, low in the east before sunrise. It's at greatest westerly (to the sun's right) elongation today.

August 30–31: Full moon is on the 30th at 4:27 A.M. The moon spends both days in Aquarius, then slips into Pisces the night of the 31st.

Editor's Note: The Sky Map in the July issue shows the constellations and stars for this month and gives the times for use.

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☐ Israel
☐ Lebanon
☐ Mexico
☐ Nepal
☐ Philippines
☐ Southern States (U.S.)
☐ Southwest Hispanic (U.S.)
☐ Sri Lanka
☐ Thailand

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4. Would you like to exchange correspondence?

If desired, correspondence can help build a meaningful one-to-one relationship. Translations, where necessary, are supplied by Save the Children.

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5. Would you like information about the child's community?

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☐ Yes ☐ No

6. How do you wish to send your sponsorship contribution?

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☐ Quarterly, $48
☐ Semi-annually, $96
☐ Annually, $192

7. Do you wish verification of Save the Children credentials?

Save the Children is indeed proud of the handling of its funds. Based on last year's audit, an exceptionally large percentage of each dollar spent was used for program services and direct aid to children and their communities. Due to volunteered labor and materials, your donation provides your sponsored child with benefits worth many times your total gift. Would you like to receive an informative Annual Report (including a summary financial statement)?

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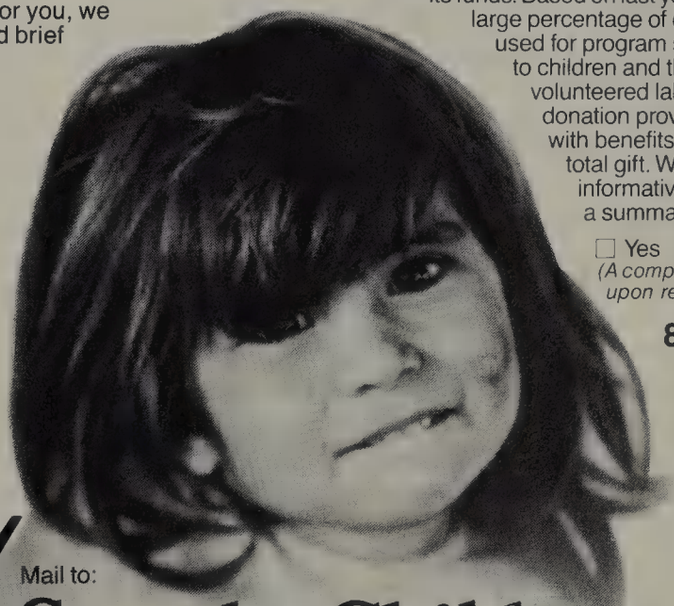
(A complete audit statement is available upon request.)



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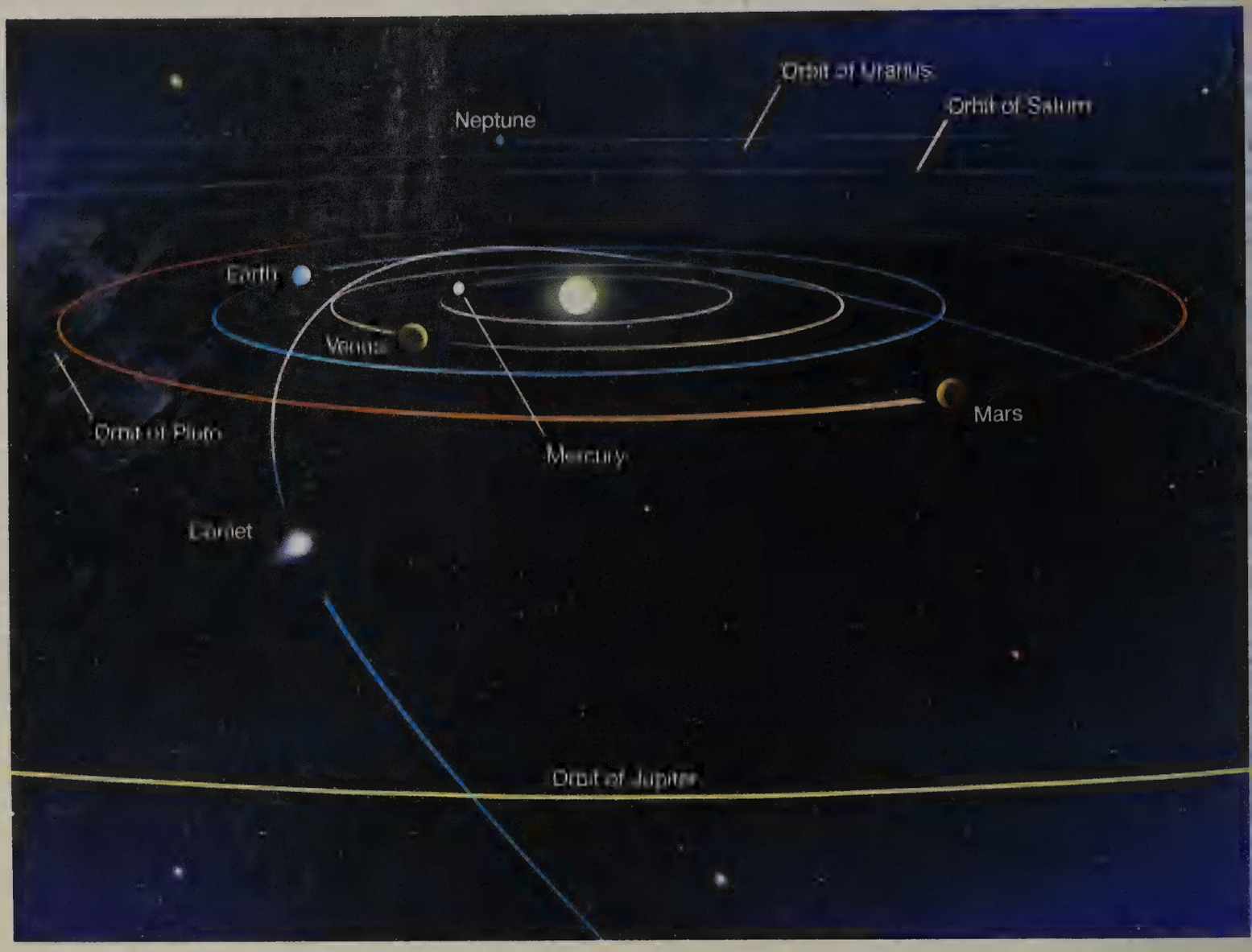

Halley's Comeback

It is still too early to see Comet Halley. That time begins in early December of this year and continues until mid-April 1986, occurring at various intervals during that period. Right now, in August, Halley's comet is still racing toward the sun and is somewhere between Jupiter and Mars, still south of the planetary planes. This month's diagram shows the comet about 273,000,000 miles from the sun, speeding toward it at 47,000 miles per hour, and 322,000,000 miles from the earth and closing with it (because the earth is moving toward the comet as well) at 103,000 miles per hour. It still has three months to go before moving inside the orbit of Mars. While its brightness is now more than doubling from month to month, it is still quite dim and without evidence of form, visible only with well-placed telescopes of sufficiently large aperture. But the time has come to plan how you may be able to see the comet when the time is right and to decide whether you want to see it badly enough to make some effort to improve your chances.

All the evidence confirms that this will not be the bright spectacular comet that history has described for us. There are some clues that the view may be better than first predicted, but not significantly so. The comet may become bright enough to be seen with the naked eye *if* conditions are favorable. But that's a big *if!* . . . if the sky is clear and free of haze and pollution, if the comet is high enough above the horizon, if the moon is down, if the sky in unobstructed by buildings or trees, and if there are no city lights or glare to obscure faint objects.

At the best time for seeing the comet (when it will be brightest in our sky next March and April), it will be deep in the southern sky, well south of the equatorial plane. That means it will be very low in the sky at mid-northern latitudes, which will seriously limit the chance of seeing it. This explains the interest in traveling south. The farther south you go, the higher the comet will be in the sky, until you get to about latitude 20° south. After that, farther travel south won't make much difference.

Even if you plan on going to a more favorable location, don't expect too much of the comet. It will not be any brighter, though it will be higher, easier to see in darker skies, visible for more hours during the night, and—if you choose your trip wisely—you may get professional help from astronomers in finding it. But with or without assistance, the best period for seeing the comet will still be from mid-March to mid-April; the very best time will be after April 3 when there will be the least moonlight.

Another advantage in traveling south in late March or April will be the opportunity to enjoy the riches of the southern sky in late summer and fall (don't forget, seasons are reversed south of the equator). The brightness of the southern Milky Way, the Southern Cross, and nearby Coal Sack, the Clouds of Magellan, and the extension of our bright winter stars down past Canopus will delight you, especially if an experienced stargazer is along to point out the significance of these deep-sky wonders that we never see from up north. If Halley's comet doesn't thrill you by its appearance, the rest of the southern sky should.

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A Blind Eye on India

Recent media depictions of the raj ignore the sexual exploitation of lower-caste women

by Pauline Kolenda

Last winter's screening season was dominated by sagas of the British in India, with *A Passage to India* at the movies and *The Jewel in the Crown* on television. Both were taken from famous novels, and both stressed a prime taboo of any caste system, the prohibition against lower-caste men—in these cases, Indians—having sexual relations with higher-caste women—in these cases, women of the British rule, the raj. The British horror of any infraction of this prohibition is expressed by accusations of rape in both *Passage* and *Jewel*. Even the possibility of friendliness between an Indian man and a British woman is shown to make members of the two opposing castes uneasy. Adela Quested's friendliness in E.M. Forster's *A Passage to India* (written and set in the 1920s) is confusing to an Indian Moslem man, Nawab Bahadur:

> "How do you do?" said Adela . . . . She held out her hand. The old gentleman judged from so wanton a gesture that she was new to his country, but he paid little heed. Women who exposed their face became by that one act so mysterious to him that he took them at the valuation of their men folk rather than at his own. Perhaps they were not immoral, and anyhow they were not his affair.

And the falsely accused hero-victim of *Jewel*, Hari Kumar, addresses this issue during a prison interrogation set in 1942 (Paul Scott, *The Day of the Scorpion*, published in 1968):

> Miss Manners was a white girl. Her friendliness towards me was of a kind that embarrassed people to watch . . . . Even someone like Lady Chatterjee was incapable of accepting immediately that a white girl could treat an Indian like a man. I found it difficult to accept it myself. For a time I thought she was making fun of me. She talked so readily. Without any kind of artificiality—or so it seemed. Just as if we'd been back home [in England]. Lady Chatterjee very naturally treated me with caution after that . . . .She probably thought I might take advantage of Miss Manners. That's the popular assumption, isn't it? That an Indian will always take advantage of an English person who is friendly.

There is, however, the other side to caste and sexuality in India. As the social psychologist John Dollard pointed out long ago, one of the features of a caste system anywhere is the access upper-caste males have to lower-caste females. While Paul Scott managed to write four lengthy volumes on the British raj with only rare hints at the other side, Rudyard Kipling was less inhibited in discussing it. In his story "Without Benefit of Clergy," he portrays a relationship between a young British official and his beloved Indian consort, and in his famous poem about the road to Mandalay, a Burmese maiden awaits her British soldier-lover.

The British historian Kenneth Ballhatchet, in *Race, Sex and Class under the Raj: Imperial Attitudes and Policies and Their Critics, 1793–1905*, mentions other facts of raj life. British military officers and higher officials were not allowed, or at least not expected, to marry until in their thirties, and marriages with Indian women were officially discouraged. British enlisted men, in contrast, because they were not expected to be able to sublimate their sexual urges as consistently as their officers, were regularly supplied with Indian prostitutes by the authorities (much of Ballhatchet's book describes the attempts to control venereal disease among the prostitutes).

In India, sexual strain between castes was not limited to that between the British as the ruling caste and the Indians as the ruled. Intercaste sexual relationships of all kinds have been a highly charged fact of Indian society, because castes, by definition, are closed communities. Indian castes are hereditary groups that are, above all, endogamous, that is, a person must marry within the caste of his or her birth to remain a fully accepted member. This feature was observed by the Portuguese, who were among the first European colonists of South Asia. The English word *caste* comes from the Portuguese *casta;* the Latin root means pure, or chaste, originally, cut off, or separated (*chaste* derives from the same root).

Marriages in India are virtually all arranged by the elders of the bride's and groom's extended families and caste communities. It is considered sinful for a Hindu father to fail to arrange a marriage for his daughter. In traditional Indian society, both rural and urban, there is widespread segregation of the sexes; in the days of nearly universal female illiteracy (up to 1900), there was almost no possibility for a high-caste marriageable girl to meet males who might be potential sexual partners. Once girls began going to school, that possibility arose, and some parents still are afraid to send their teen-age daughters on to middle school or high school, where they might meet male students, teachers, or passers-by. A small scandal erupted in one provincial town in south India, where I lived in the 1970s, when the girls attending an all-girls' high school at a local Catholic convent were discovered writing love letters to the driver of the bus they rode to and from school.

In the traditional situation, where women of higher caste were carefully secluded and guarded from lower-caste men, women of lower caste who had to leave their homes to do their work were often considered to be fair game for upper-caste men. This sexual expression of the power of high caste over low operated even in the non-British reaches of the caste system and continues to operate today in village India, where the vast majority of the population still lives.

In one village in northern India, where I lived in the mid-1950s and to which I returned in 1984, the dominant caste is called Rajput (literally, "sons of kings"). Rajputs control most land and its cultivation, and hence the distribution of food. The other village castes consist of various kinds of artisans or service specialists—

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weavers, carpenters, shoemakers, laundrymen, sweepers, barbers, and water carriers. The heart of the village caste system as an economic system is a series of exchanges between the dominant caste and the specialist castes.

Under British rule, and still in the 1950s, the Rajputs depended heavily on the Chamar caste to till their fields. The Chamars acted as agricultural servants, receiving pay in return. (Since the 1950s, land shortages due to population pressure and increased mechanization of farming have made this arrangement less common.) Because they are historically identified as leather workers, Chamars are among the lowest castes in the hierarchy—untouchables, as they are known in English. In Indian languages such groups are referred to by a term that usually translates as "unclean" (Hindus regard working with leather as unclean).

The village is considered to belong to the Rajput caste, and Rajputs do own most of the cultivable land. Members of other castes, even though their ancestors may have settled in the village hundreds of years ago, are considered to be guests, there at the invitation of the Rajputs and remaining there by their grace. Rajputs have resorted to violence to insure their village rule, and that violence is sometimes expressed in rape and sexual exploitation of lower-caste women.

Ram, a Chamar elder whom I interviewed in the mid-1950s, told me of various such incidents. He described an event that probably took place in the 1920s:

> The Rajputs try to laugh down honest people. There was a young potter bride. Rajput men tried to force her into adultery, but she did not agree. She tried to avoid that path. They offered her money, ten or fifteen rupees. Even then, she did not agree. Three Rajputs got her by force. She had just had her final marriage rite, and she was very beautiful. When she did not agree, they trapped her in a house by force and raped her there. When they finished their bad work, they put the rupees on her body and slapped them, and said, "Don't you need this money?"

Ram reported that a Rajput man might push an untouchable woman's husband out of his own house, the Rajput raping the wife with full knowledge of the helpless husband.

Early in the twentieth century, lower-caste villagers did own small parcels of land, but it became more difficult for them to retain ownership as population pressure increased. Ram told me of a Chamar who owned about twenty-five acres. In the early 1940s he quarreled with some Rajputs whose land he had to cross to reach his own. The upshot was that these Rajputs refused to let him cross their land. They also tapped so much water from the common irrigation canal that his land was left dry. They let their cattle go into his fields, and they cut his partly grown sugar cane. A group of them even attacked the Chamar and some of his relatives. The pressure mounted so that the Chamar eventually sold his land. Still, there was resentment on the part of some of his Rajput enemies because he had not sold some of the land to them. Soon thereafter (by now about ten years after the initial quarrel), the Chamar's grandson brought his bride home from their final wedding rite. As they came from the railroad station in the nearby town, they met two enemy Rajputs, coming from the sugar mill. The Rajputs beat the husband senseless, and they took the bride into the sugar cane fields and raped her.

Ram, who spoke of these incidents, believed that in times gone by, the Rajputs had been protectors, rather than exploiters, of the lower castes:

> The Rajputs used to be good. They would see our mothers and daughters with good hearts. Now they don't. Therefore, they are less powerful. They saw the poor and gave things. Now they don't. They were more powerful then. It used to be that if anyone who was more powerful than we troubled us, the Rajputs used to protect us. They would face the powerful ones troubling us. Now, they themselves suppress us.

The loss of noblesse oblige that Ram perceived may reflect a change in Rajput attitudes that occurred when their dominant position was challenged by Gandhian, Congress Party, and other reformers who, from the 1920s to 1950s, worked to elevate the lot of untouchables. Ram was suggesting the reverse interpretation, however. A traditional Hindu idea is that when people do not follow their dharma, or religiously given duty—which includes the protection of those dependent upon them—their physical and social conditions are greatly weakened.

Not all intercaste sexual relations in the village were forced upon the lower-caste women, of course. Some women established long-standing affairs with higher-caste men. A relationship could begin when a Chamar women was cutting fodder or cane in the fields or as she went about selling bundles of fodder to the higher-caste men at their cattlesheds. Such an eventuality was strongly disapproved of by the members of the woman's family. Ram told of a Chamar woman who used to go to her Rajput lover. When her husband's younger brother went to the Rajput's cattle yard to take her back, he was beaten by four or five of the men in the Rajput household. He finally had to flee the village.

Then there was the case of an untouchable sweeper woman who began a love affair with a Rajput back in the 1930s. The young couple became notorious when their relationship was exposed by an older sweeper woman who discovered them making love in a cattleshed. The two, their faces covered with lampblack, were paraded about the village on donkeys as a rite of humiliation. Then both were driven out of the village. But eventually they returned and were accepted back by their respective caste communities. When I was there in the 1950s, the woman was a widow in her forties. Gossip had it that the affair continued and that whenever the woman was involved in a dispute with other sweepers, she would call on the protection of her Rajput lover.

While probably neither the British nor Indians were consistently strict about illicit intracaste connections, both generally felt dishonored when sexual relations crossed caste lines. But the morality of the caste system is only partially portrayed in *A Passage to India* and *The Jewel in the Crown,* which ignore the sexual exploitation of lower-caste women. The bitter irony of the caste system is caught in a remark that Ram made to me: "The Rajputs are ever ready to have contact with our women, but with us men, they don't even let us touch their clothes."

The motives for exploiting lower-caste women were not the same for the Rajputs and the British, however. Among the Rajputs, women of lower castes were substitutes for prostitutes of whom there were none in the village. And rape of these women was an act of dominance indicating that the lower castes were defeated communities, with no right even to the belief in the chastity of their women. The British, instead, endured their enlisted men's sexual exploits with Indian prostitutes because they preferred to keep these men single. That way the soldiers would be unencumbered with family responsibilities as they risked their lives in battle; in addition, the military service budget would be relieved of the costs of the families' upkeep. Marriage between the British and Indians was specifically discouraged because, as Ballhatchet concludes, "rulers should be aloof from the people and so trusted as beyond corruption and feared as remote from the common ways of common men."

Pauline Kolenda is a professor of anthropology at the University of Houston, University Park.

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Cranberry Glades, West Virginia

by Robert H. Mohlenbrock

Some of West Virginia's Monongahela Forest is so dense that summer sunlight doesn't reach the forest floor. At higher elevations, where the climate is cool, rainfall abundant, and fog common, the tree cover is provided by red spruces, yellow birches, and balsam firs. Sugar maples, beeches, basswoods, and white pines dominate the mountain ravines. There are even a few virgin stands of red spruce, where trees three to four hundred years old have been spared from lumbering. With so much unbroken forest, one vast opening, where only the occasional tree rises above a sea of low-growing vegetation, provides a startling inconsistency. This is Cranberry Glades, a bowl-shaped, boggy area at the foot of three mountains—Cranberry, Black, and Kennison.

The basin containing Cranberry Glades is about three miles long and up to one mile wide and about 3,400 feet above sea level. Penetrating the heart of the glade are Cranberry River and its tributaries, Charles Creek and Yew Creek. Cranberry River, which originates from springs halfway up Cranberry Mountain, never spreads more than twelve feet across. Four treeless bogs, ranging in size from eight to sixty acres, are scattered through the basin. The rest of Cranberry Glades consists of dense thickets of shrubs or bog forests.

The four bogs have a layer of peat that may reach a depth of eleven feet. Peat (dead sphagnum moss that has sunk beneath a mat of living sedges and heaths) builds up where there is insufficient oxygen to promote the complete decay of vegetable matter into soil. Beneath the peat in Cranberry Glades is usually a layer of algal ooze that may be another two feet thick. This is a dark, jellylike material, the decomposed remains of algae that lived tens of thousands of years ago. During spring, the water table may come within an inch of the peaty surface, while in autumn, it drops nearly one foot.

Bogs often form in lakes where poor drainage allows organic detritus to accumulate, principally from sphagnum moss that grows along the water's edge. Early explorers in the glades thought that the wet basin was once a natural mountain lake, probably one that resulted when a landslide created a dam. The evidence, however, casts doubt on their theory. Since the downstream end of the glade is nearly fifty feet lower than the upper end, and is five hundred feet wide, the area could not have been flooded unless a landslide built a dam fifty feet high and five hundred feet wide. There are no remnants of any such dam. In addition, the deepest peat is at the upper end of the basin. If lake waters once covered the entire area, the thickest layers of peat would be at the lower end, where the water would have been deepest. Finally, some parts of the glade do not have peat deposits, an unlikely occurrence if the bog had developed in a lake.

H.D. Darlington, a biologist who studied the Cranberry Glades extensively, noted that the peat varied in thickness throughout the glade and was absent under the streams. If the basin had been covered by a lake, there would be peat under the streams today. Darlington theorized that sediments formed levees along the streams; whenever the streams then overflowed, water was trapped in low-lying areas outside the stream banks. Thick accumulations of peat developed in these basins. Darlington also proposed that some peat may have been deposited in stream beds abandoned when drainage patterns shifted. Even in recent times, there is evidence that the Cranberry River has been straightening its course, eliminating some of its old meanderings.

Peat is so acidic that most of the plants that flourish in the adjacent mountain forests are unable to grow in the bogs. Plant life in the open bogs is dominated by two species of cranberries, which are trailing evergreens whose rosy summer flowers develop into tart red cranberries by September. (The species producing the larger berries is the same as that harvested commercially.) Both of these bog-inhabiting plants of the heath family are more common in the northern states and Canada. Another heath that grows in the open bogs is the bog rosemary; its presence marks the southernmost place in the world where it grows naturally. Fungi living on and in the roots of the heaths and other bog-inhabiting plants help them survive by making available nutrients that, in acidic conditions, are not generally found in usable form. Biologists call this mutually beneficial relationship *mycorrhiza.*

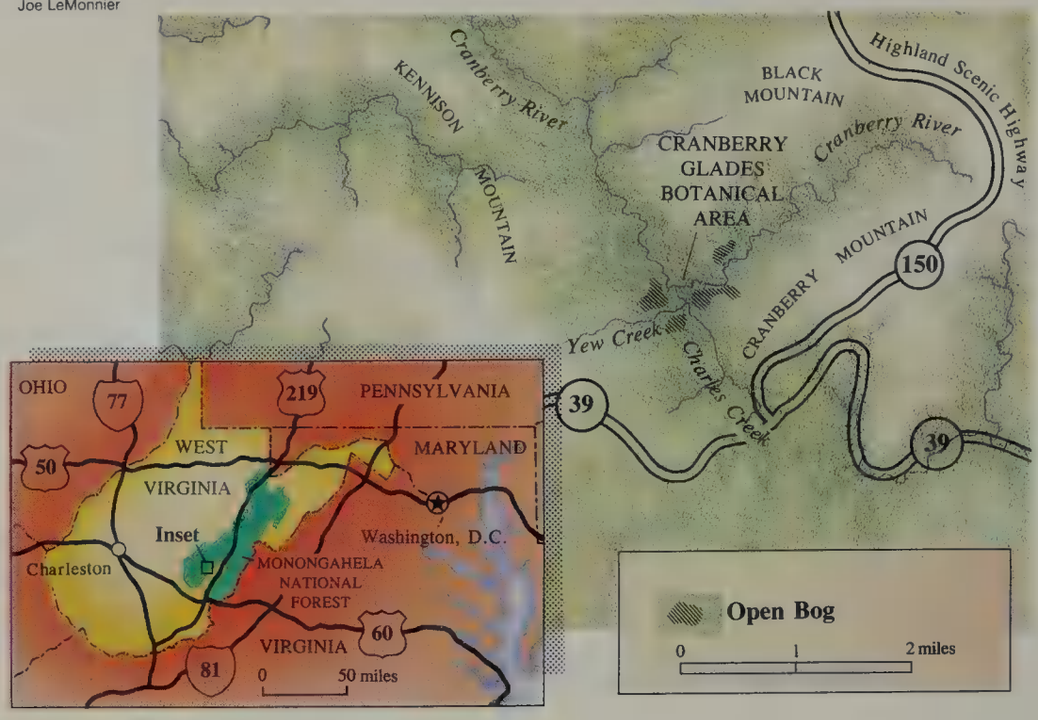
During spring and summer, the open bogs are green, punctuated by occasional flashes of yellow from the showy flowers of the swamp candle and pink from two kinds of wild orchids. In autumn, however, white dominates the vegetation, appearing like a blanket of light snow. Flowers of the white-top aster blend with the smaller milk-white flower clusters of the beaked rush, and the seed heads of cotton grass are entangled in masses of hairs.

Nonflowering plants, such as mosses and lichens, hug the surface of the peat. The mosses are so abundant in places that they form small mounds known as hummocks. The mosses and lichens are in constant competition. During extended periods of rain, the fast-growing gray lichens spread over the green mosses, forming an intricate parquet. But in dry weather, the lichens crumble into powder, and the mosses surge over their desiccated tissues.

Surrounding part of the open bogs are almost four hundred acres of a nearly impenetrable thicket of slender-branched shrubs. There are twelve different kinds of shrubs, including the swamp rose and the speckled alder, whose stems are covered by conspicuous white-blotched pores that assist the plant in the exchange of gases. In summer, great masses of white woolly aphids cover the alders, giving the thickets a stark and eerie appearance. Beneath the shrubs grow a diversity of wildflowers that provide a year-round display, from the

David Muench

Joe LeMonnier



skunk cabbage, which forms its fetid flowers while snow still covers the ground in February, to the aster, turtlehead, and monk's-hood, which flower in the fall.

Sometimes lying between the wet alder thickets and the rich hardwood forests of the surrounding mountains is a bog forest where red spruce, Canadian hemlock, yellow birch, and black ash grow above a soggy forest floor covered by wood sorrel and mosses. From the branches of the bog forest trees hang long festoons of the *Usnea* lichen, reminiscent of the totally unrelated Spanish moss.

The encroachment of woody plants from the surrounding shrub and forest communities is a major threat to the open bogs. Shrubby Saint Johnswort is particularly aggressive, but chokeberry and winterberry are invading at a rapid rate. Most trees cannot establish themselves in the bogs because they can't find firm anchorage, but a few have reached maturity where conditions are favorable. Some West Virginia botanists speculate that in just a few hundred years woody plants will transform the entire basin into a bog forest.

Until a few years ago, Cranberry Glades was several miles from the nearest public road and virtually inaccessible, except to the ardent hiker. Today, however, the Highland Scenic Highway passes near the Glades, a modern visitors' center has been erected nearby, and a short boardwalk has been provided. The boardwalk passes through a bog forest and an alder thicket before cutting across the corners of two of the open bogs. It not only protects the sensitive ecosystem from indiscriminate trampling but also keeps visitors from miring-in up to their waists.

Cranberry Glades

For visitor information, write:
Forest Supervisor
Monongahela National Forest
Box 1548
Elkins, West Virginia 26241
(304) 636-1800

"This Land" highlights the biological phenomena of the 153 U.S. national forests. Robert H. Mohlenbrock is distinguished professor of botany at Southern Illinois University at Carbondale.

David Muench

Most trees cannot grow in Cranberry Glades' boggy soil, but woody plants may eventually transform the entire basin into a bog forest.

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An adult rusty crayfish
All photographs by Doug Stamm/PROPHOTO

Lake-Bottom Tyrant

Aggressive and prolific, the rusty crayfish has clawed its way to the top of the food chain in northern Wisconsin lakes

by David M. Lodge, Annamarie L. Beckel, and John J. Magnuson

At their summer camp on Long Lake, Wisconsin, the Girl Scouts had to retreat from the water; they could no longer swim without being constantly pinched by crayfish. That was in the mid-1960s. While certain crayfish had always lived in the lake, local residents recognized the current nuisance as a newcomer. Plant life was also under attack. Dense beds of aquatic vegetation, such as the rich patches of musky weed that had always attracted fish and fishermen, simply disappeared. The crayfish ate their way northward from the far end of the lake, leaving a few tough-stemmed waterlilies and an otherwise barren lake bed in their wake. The culprit was *Orconectes rusticus,* the rusty crayfish.

A few years later and 120 miles to the northeast, property owners and fishermen witnessed the decline of Lake Metonga, known throughout Wisconsin as a hot spot for walleye and perch. The lake teemed with crayfish, and vegetation dwindled every year. By the late 1970s, walleye no longer successfully reproduced. Soon all the weed beds in the lake were gone. By 1983, the Wisconsin Department of Natural Resources (WDNR) had spent $17,000 to stock the lake with walleye and lend support to a citizens' group that was trying to bring back aquatic plants. The rusty crayfish had struck again.

The rusty is one of three, originally southern species of crayfish that are relatively recent immigrants to Wisconsin lakes. Fifty years ago, the fantail (*O. virilis*) was the only species present, probably having reached this region through natural migration up tributaries of the Mississippi. Then the blue crayfish (*O. propinquus*) appeared and flourished. But only within the last thirty years has the rusty crayfish left its southern home and invaded the lakes of northern Wisconsin.

The rusty probably got a free ride from Illinois and Ohio fishermen vacationing in the Wisconsin lake district. Live crayfish were a favorite bait until their use was outlawed in 1983. Fishermen hardly foresaw ecological disruption when they dumped their extra bait, including rusties, into the lake at the end of the day. When commercial trappers, who had long sought and sold "crabs" within the state for bait and human consumption, discovered the prolific rusty crayfish, they gave the migrant a helping hand, broadcasting the rusty into some isolated lakes the crustacean might not otherwise have easily reached. Such practices accelerated the rusties' advance, and the crayfish proceeded to thrive beyond anyone's expectations.

While its predecessors, the fantail and blue, appear to be benign members of the ecological community, the rusty crayfish has become notorious in northern Wisconsin, thriving at the expense of native crayfish, plants, and fish. What physical and biological constraints prevent the fantail and blue from dominating their surroundings, and what traits enable the rusty to establish a lake-bottom dynasty?

A team of biologists from the University of Wisconsin at Madison Center for Limnology has undertaken a long-term ecological study of lakes subject to rusty crayfish depredation. As part of that team, we have used the lakes as a natural laboratory for the past ten years to investigate the habits and interactions of the fantail, blue, and rusty crayfish.

These three kinds of crayfish are similar in appearance, behavior, and habitat preference. Northern Wisconsin lake habitat is like that of the streams occupied by *Orconectes* species farther south. The well-oxygenated water has adequate calcium, enabling crayfish to maintain their calcium carbonate exoskeleton. All three species favor shallow areas of fist-sized rocks, called cobble, where each individual selects and defends a lake-bed shelter. Typically, a crayfish excavates a cave under the edge of a rock or sunken log, leaving a small mound of sand and gravel at the opening. The crayfish then backs into its home, leaving only its eyes and massive pincers (or chelae) visible, and warily watches its lacustrine world. Most crayfish remain in hiding during the day and emerge to forage only at night.

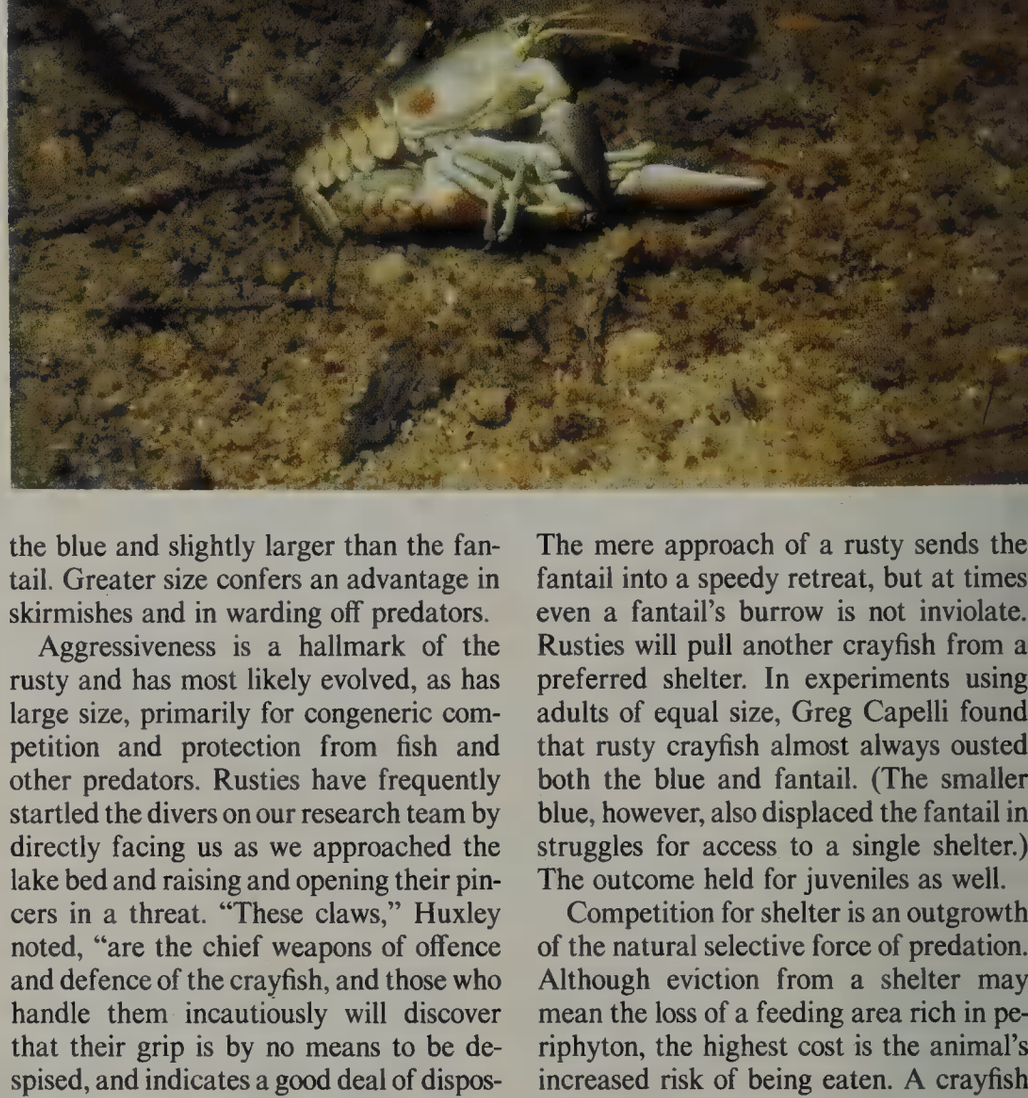
In an 1880 monograph, Thomas H. Huxley described crayfish as opportunistic and enthusiastic feeders:

> Larvae of insects, water-snails, tadpoles, or frogs, which come within reach, are suddenly seized and devoured, and it is averred that the water-rat is liable to the same fate. Passing too near the fatal den, possibly in search of a stray crayfish, whose flavour he highly appreciates, the vole is himself seized and held till he is suffocated, when his captor easily reverses the conditions of the anticipated meal.

Huxley may have overstated the case in regard to live small mammals on the crustacean's menu; but crayfish do vigorously attack vulnerable animals. Large prey, typically fish, are usually sick or dying when attacked. Stories abound of rusty crayfish reducing fish to bones in an hour. Crayfish use their chelae and the small pincers on their first two pairs of walking legs to reduce large pieces of food to a whirling cloud of small particles.

Yet crayfish are omnivores. Although they seek out high-protein animal food, such as fish eggs, carrion, and insect lar-

Crayfish in Wisconsin lakes may mate at any time from late summer to early spring. The female stores sperm in an abdominal pocket until she is ready to lay up to 200 eggs in April or May. The offspring of rusty crayfish typically hatch earlier and grow faster than blue and fantail young. Below: Adopting a mating posture atop a female, a male rusty crayfish holds down her powerful pincers with his own.



vae, much of their diet consists of generally more abundant but less nutritious plant food. At night, they scrape periphyton, or "scum flora," a complex green or brown film of organic detritus, bacteria, and algae, from the surface of rocks. As Huxley points out, "Few things in the way of food are amiss to the crayfish; living or dead, fresh or carrion, animal or vegetable, it is all one."

These three *Orconectes* species have a similar life cycle. Like other crustaceans, crayfish periodically molt, shedding and re-forming their hard exoskeleton to allow for growth. Adult male *Orconectes* molt at least twice a year: into nonbreeding form in early summer and reproductive form in late summer. Mating may take place at any time from late summer through early spring, but the female stores sperm in a pocket in her abdomen until April or May. She then lays as many as 200 eggs and fertilizes them externally. They remain attached to her abdomen until they hatch into bulbous-headed, thin-tailed pink juveniles. The young remain close to the female for about two weeks, molting several times and gradually taking on the appearance of miniature adults.

In 1980, Greg Capelli, of the University of Wisconsin, surveyed eight area lakes that in 1975 had low populations of rusty crayfish and relatively high populations of fantails, blues, or both. During the five-year interval, the number of rusty crayfish had increased in seven of the eight lakes, and fantails and blues had declined proportionally. In lakes subject to a population explosion of rusties, fantails and blue crayfish were virtually nonexistent.

From the start, the rusty crayfish has an advantage over its other *Orconectes* lake mates. Its eggs hatch earlier in the spring than blue and fantail eggs and its young grow faster. During dives under the ice in April, Jim Lorman, of the University of Wisconsin, observed many rusties already carrying eggs. Quicker growth means that rusty offspring are bigger than immature blues and fantails of the same age. Rusty males have large chelae, and at maximum adult proportions (four inches from head to tail, plus about half that length in chelae) the rusty is considerably larger than the blue and slightly larger than the fantail. Greater size confers an advantage in skirmishes and in warding off predators.

Aggressiveness is a hallmark of the rusty and has most likely evolved, as has large size, primarily for congeneric competition and protection from fish and other predators. Rusties have frequently startled the divers on our research team by directly facing us as we approached the lake bed and raising and opening their pincers in a threat. "These claws," Huxley noted, "are the chief weapons of offence and defence of the crayfish, and those who handle them incautiously will discover that their grip is by no means to be despised, and indicates a good deal of disposable energy." Like the bathers at Long Lake, we have been pinched, with blood drawn, by defiant rusties standing their ground and resisting capture.

Trout Lake, site of a small but expanding rusty crayfish population and the largest of the lakes in the Northern Lakes Long-Term Ecological Research Project, is now the focus of a time-course study. Experimental results from our laboratory at the lake help explain how behavior, as well as physical attributes, enables the rusty to literally dislodge competitors. The bullying rusty is more than a match for the relatively docile, easily handled fantail. The mere approach of a rusty sends the fantail into a speedy retreat, but at times even a fantail's burrow is not inviolate. Rusties will pull another crayfish from a preferred shelter. In experiments using adults of equal size, Greg Capelli found that rusty crayfish almost always ousted both the blue and fantail. (The smaller blue, however, also displaced the fantail in struggles for access to a single shelter.) The outcome held for juveniles as well.

Competition for shelter is an outgrowth of the natural selective force of predation. Although eviction from a shelter may mean the loss of a feeding area rich in periphyton, the highest cost is the animal's increased risk of being eaten. A crayfish exposed on the lake bottom is much more likely to become a meal than one hidden under a rock, and during molting and one to two days afterward, the "soft shell" crayfish without a shelter is completely defenseless. Although many birds and mammals eat crayfish, fish are the most common predators. As a crayfish grows larger, little fish, other crayfish, and dragonfly larvae no longer pose a threat. Only large fish, particularly mature smallmouth bass, hunt adult crayfish. By dominating available shelters, the rusty more easily escapes predation. Fish predators also determine to a degree the behavior of

A rusty crayfish feeds at night on a stand of long-stemmed water plants. In some Wisconsin lakes, grazing by rusties has nearly eliminated vegetation and plant-dependent invertebrates, such as snails.

heir smaller crayfish prey and may hereby indirectly affect the growth of periphyton and water plants. In studies by ecologist Roy Stein, now of Ohio State University, smaller crayfish, such as the adult blue, responded to the presence of fish predators by remaining in shelters and curtailing feeding. Under the pressure of predation, the fantail, blue, and to a lesser extent, the rusty crayfish are less active and eat fewer plants. Sizable crayfish, however, especially rusty males, can often feed with impunity on open, sandy lake bottoms, even in daylight. Few fish are large enough to tackle the biggest rusties; those that try are often easily dissuaded by the defensive display of pincers. Like Huxley, we on the study team have seen the tables turned on would-be predators; if a smallmouth bass fails to launch its attack from the rear, the bass may end up trying to shake off a persistent crayfish that has clamped onto its lips.

The rusty crayfish, then, can evade capture and drive competitors into the mouths of predatory fish by expropriating available shelters. But a more subtle mechanism of species replacement may also be at work. In some lakes, many crayfish show characteristics intermediate between the rusty and the blue crayfish. Whether these individuals are fertile and whether they rank high in competitive ability remain to be seen, but their existence is strong evidence for ongoing hybridization.

Crayfish recognize members of their species and opposite sex partly through pheromones, the signal-sending chemicals also used by many insects. Male rusty crayfish more often misidentify others of their kind than do blue and fantail crayfish, a mistake that works to the rusty's advantage. Greg Capelli discovered that rusty males frequently mate with blue and fantail females. If these unions leave a sperm plug in the female's sperm storage pocket, she may be prevented from mating later with a male of her own species. Blue and fantail males, however, do not make the same mistake with rusty females, which are therefore inseminated only by rusty males. So with little damage to their own reproductive success, rusty crayfish undermine the reproduction of competing species.

Some rusty populations have attained densities of thirteen adults per square yard. Populations of the similar-sized fantail never reach such a level; those of the smaller blue, however, sometimes do. But the rusty crayfish's size gives it a total living biomass that far exceeds those of its two competitors. Larger size, longer feeding periods, and greater use of different substrate types, such as open, sandy lake beds and soft sediment bottoms, account for the rusty's more obvious effects on its plant and animal foods.

To compare the effects of fantail and rusty crayfish on large aquatic plants, or macrophytes, we enclosed separate populations (of equal number and biomass) of both species in a rich plant community on the bottom of Sparkling Lake. In the summer of 1983, we regularly counted the plants remaining within each of twelve crayfish corrals; four enclosures had populations of fantails, four had rusties, and four contained no crayfish. Both species ate macrophytes, favoring some plants over others, and both ate a similar amount of vegetation. Therefore, the heavy impact of the rusty crayfish is probably not due to rapacity, but to its decreased predation risk and increased densities.

Using similar experimental methods, we compared the growth of plants in crayfish-free enclosures to that of plants subjected to grazing by ten rusty crayfish per square yard. By the end of summer, only water celery remained in the enclosure with crayfish. A dense mixture of four to five macrophyte species persisted in the nongrazed corrals. Not only did the rusty crayfish consume all plants except water celery, they also devastated the invertebrate animals that live on plants. For example, a snail commonly associated with aquatic plants was abundant in the ungrazed enclosures but absent from corrals with crayfish. Such elimination resulted largely from a combination of direct predation on snails and plant destruction.

Can even low densities of rusty crayfish make serious inroads on growth of food plants? To find out, we placed crayfish cages in an area of Trout Lake with thick stands of macrophytes. At population densities of one crayfish per square yard—a density commonly exceeded in nature—the biomass of aquatic plants was reduced by 40 percent. At a density of ten crayfish per square yard, not a single plant stem remained after twelve weeks. The data gathered allow us to make relatively precise and disturbing predictions about the alteration of ecological communities in Trout Lake as the rusty crayfish advances.

Abundance and diversity of aquatic plants and invertebrates diminish as a direct result of crayfish grazing and predation. In the past, macrophyte and periphyton primary production has fueled the secondary production of insects that fed small prey fish that in turn were eaten by large sport fish. This food chain is now being short-circuited at two levels. Crayfish now consume the plants, replacing other invertebrates as the top grazers. Snails and insects that use the remaining plant habitat are also liable to be eaten by crayfish, rather than by small fish, as they were in the past. Through the consumption of those invertebrates and of fish eggs, as well as destruction of habitat, crayfish are replacing small fish, and ultimately bass, walleye, and muskellunge as the top predators.

A horde of blue and fantail crayfish, feasting by night on a dead fish, will rapidly reduce it to bone. In lakes invaded by rusty crayfish, blue and fantail populations have declined.

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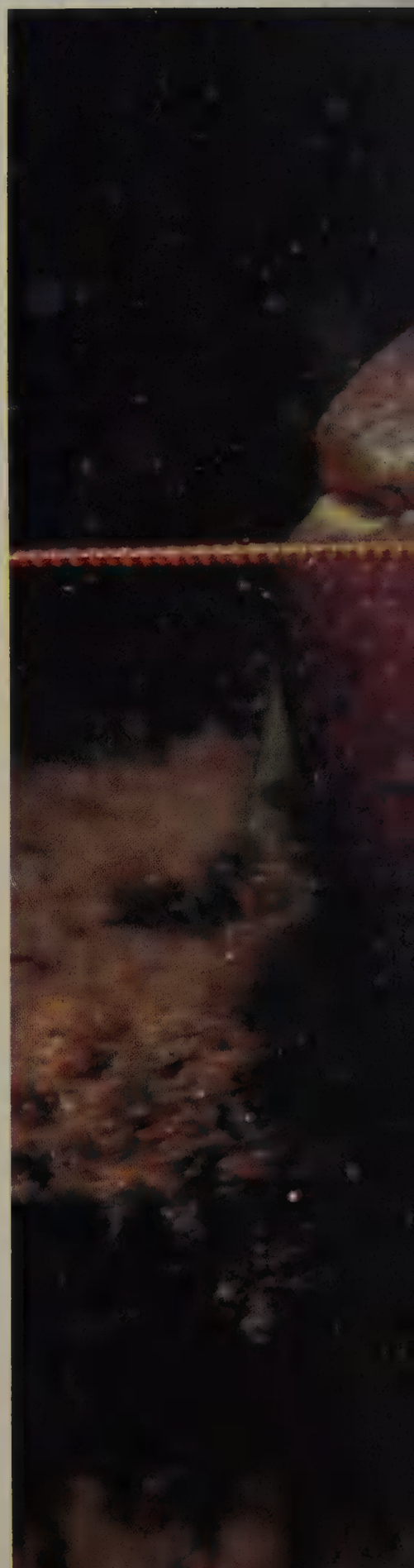


The shorter the food chain, as vegetarians point out, the greater its overall efficiency. But the end product of the new food chain in northern Wisconsin lakes—the rusty crayfish—is not as popular as walleye and musky. If adult rusties were more easily caught and readily consumed by these and other sport fish, such as lake trout and smallmouth bass, northern lakes might sustain more such desirable fish. As fish food, the rusty is a high-protein packet, but an evasive one, which is sheathed in a heavy, indigestible covering. Consequently, crayfish, especially adults, may not be a preferred or optimal diet for fish, but the harvesting that is a growing part of Wisconsin's economy is providing an increasingly popular item for humans.

Harvesting crayfish may provide a novel food and jobs, but it is unlikely to significantly reduce the crayfish population. Current trapping methods catch mostly males, but leave enough to fertilize the females, which in turn have less competition from males for food and shelter. The result is a continued crayfish boom. Underwater fences are expensive and at best only temporarily effective. Poisons developed to exterminate crayfish would most likely also destroy many other animals, especially zooplankton, tiny crustaceans that are an important food source for small fish. The most effective and harmless way to reduce crayfish populations would probably be to protect populations of predatory fish. Unfortunately, the very goal of crayfish control is to allow a continued take of sport fish. Perhaps the best solution is to wait for other natural interactions to rein in the rusties, and in the meantime, to encourage commercial exploitation of crayfish.

In ecological and social terms, the consequences of the rusty crayfish influx will be greater than those of the two pioneer *Orconectes* crayfish in northern Wisconsin and rusty-ridden parts of Minnesota, Michigan, and Ontario. Our perceptions may change, however, as societies both in and outside the lakes adjust to the new member of the food chain. The fantail and blue crayfish became integral parts of the ecological communities they joined, but perhaps only after local predators and parasites had learned to exploit them and local prey plants and animals had responded to the selection pressures they exerted. The natural course in the case of the rusty remains to be seen. This animal invasion has provided insights into the roles of competition, predation, and herbivory in lake communities, but it may be quite a while before humans and crayfish in northern Wisconsin come to terms. □

A rusty crayfish scrapes "scum flora," or periphyton, a complex film of organic detritus, bacteria, and algae, from the surface of a submerged log. Although crayfish are quickly attracted to carrion and live insects, most of their diet consists of less nourishing but abundant periphyton.

The World of Robert Bateman

When I think of Robert Bateman, three images come to mind. The first and dominant one is of the artist in his studio. On the easel is a large painting of a tiger. In the early afternoon the great cat had loomed dramatically from the painting; within an hour or so it had retreated behind a screen of reeds. On the artist's lap is a smaller painting of a hawk. As he talks, he works on both paintings, moving casually from one to the other—the same brush painting the same color on little sections of each, although they are totally different in subject, scale, and tone. Beside him, to his right, is a little trolley with his paints and brushes and sponges and water. As he works, he wipes his brush off on the underarm of his old sweater. He wears a visor against the studio's fluorescent lights, which are gradually taking over from the fading afternoon light coming through the large windows.

The second image is of the artist in the field. In a gentle, misty rain, Robert Bateman is stumbling up a slippery mountain creek bed. Encumbered with a camera on a tripod, a sketchbook, and an umbrella, and wearing an Irish tweed hat, a slicker, and bright yellow rain pants, he is a pleasantly bizarre figure, reminiscent of the eccentric nineteenth-century field naturalists. He looks at everything: the lush vegetation, the texture and colors of lichens on the rock, the quality of the light.

The third image is of Bateman the public figure. Genial and dapper, with only a slight aura of the studio and the out-of-doors, he is lecturing to a large audience at one of the openings of the hugely popular exhibition of his paintings that has been touring Canada and the United States for the past three years.

On occasions such as these, he is likely to tell the story of his career as an artist. He does this in an easy, self-deprecating manner, showing slides of his paintings, starting with some of his childhood works. This talk traces the various stages of his career as an artist and is also an easy lesson in how to look at a Bateman painting.

Bateman was born in 1930 and grew up in Toronto when the countryside was closer to the city than it is now and the ravines beside his family home were filled with small wildlife and migrating birds. He became obsessed with both art and nature at an early age and spent most of his youth drawing, painting, and learning about the local bird and mammal life. His paintings from these years clearly relate to his mature work: the animal subjects are not confronting or responding to a human viewer, and there is a careful and knowledgeable presentation of the surrounding habitat.

At that time, Toronto's Royal Ontario Museum was beginning its fine program for budding artists and naturalists, and all of Bateman's early training came from its accessible and able staff. By the time he was seventeen he had an excellent general knowledge of North American bird, mammal, and plant

life. This was augmented by summer jobs with wildlife research teams in Algonquin Park in northern Ontario and later, during his university and post-graduate years, on biological and geological field parties in Newfoundland, Ungava in northern Quebec, and on Hudson Bay. Travel, generally focused on wildlife biology, became important to him. His first journeys took him around North America, then to Europe, and ultimately, when he was in his late twenties, around the world on a year-long journey in a Land-Rover.

By the late 1970s, Bateman was recognized as one of the world's outstanding artists in the field of animal art. Since then, his paintings have become enormously popular and he has achieved a degree of public celebrity. He is an insatiably curious naturalist, a willing teacher, and a dedicated conservationist, but he remains an artist first and foremost.

Ramsay Derry

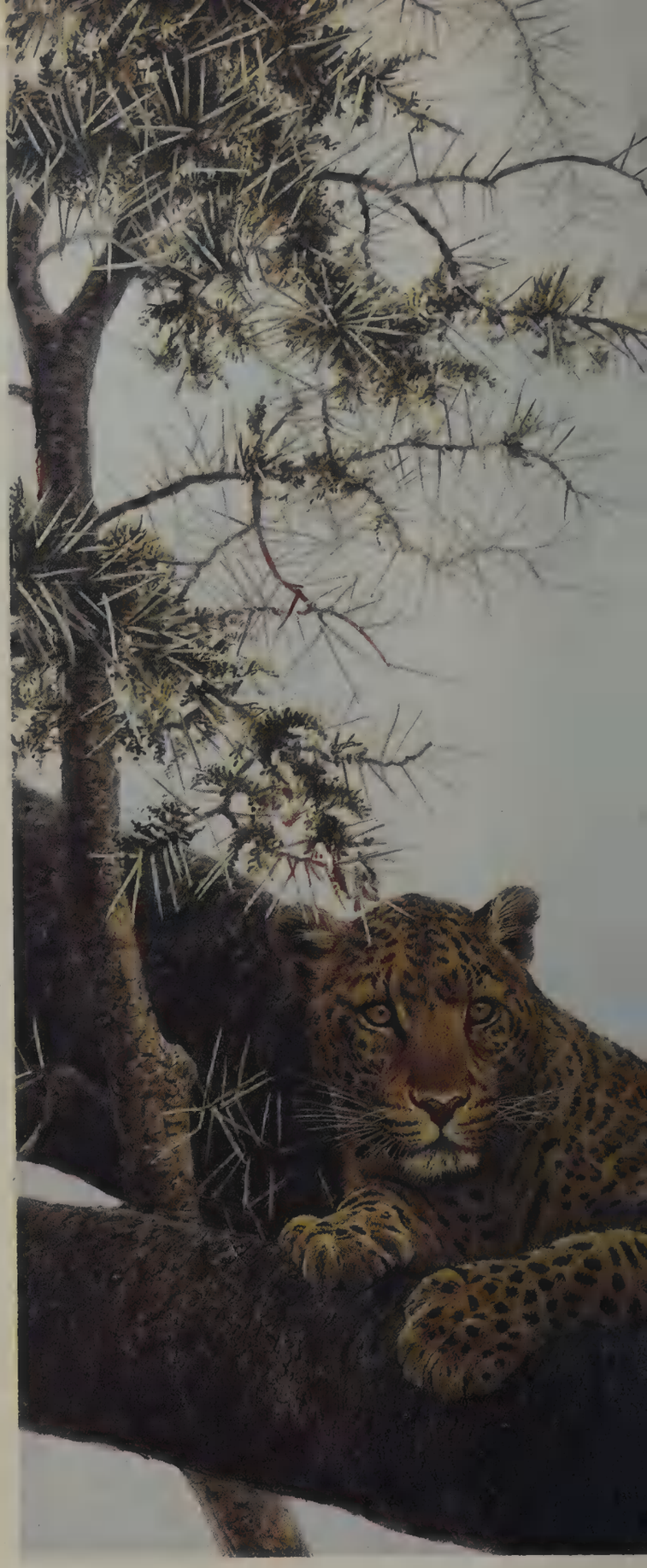
From the forthcoming book *The World of Robert Bateman*, text by Ramsay Derry. Text and compilation copyright ©1985 by Madison Press Books. Artwork copyright ©1985 by Boshkung, Inc. To be published by Random House, Inc.

"I can't conceive of anything being more varied and rich and handsome than the planet Earth. And its crowning beauty is the natural world. Whether it's here in Ontario or in the Antarctic or in Africa, I want to soak it up, to understand it as well as I can, and to absorb it. And then I'd like to put it together and express it in my paintings. This is the way I want to dedicate my work."

Robert Bateman, 1981

ELEPHANTS

"When I saw this gnarled old stump it seemed to me a whole world in itself. The insect tunnels and the wear and tear of weather and age fascinated me and became the driving force for this painting. The shape and texture of the stump and its curving dead root suggested elephants as a related subject. Even at a distance, elephants are impressive animals, but they usually prefer to keep some kind of cover between you and them, particularly if they've got young ones with them. I put them behind a screen of scruffy, chewed-up trees and they are also veiled by the dust that they normally stir up when disturbed."



LEOPARDS

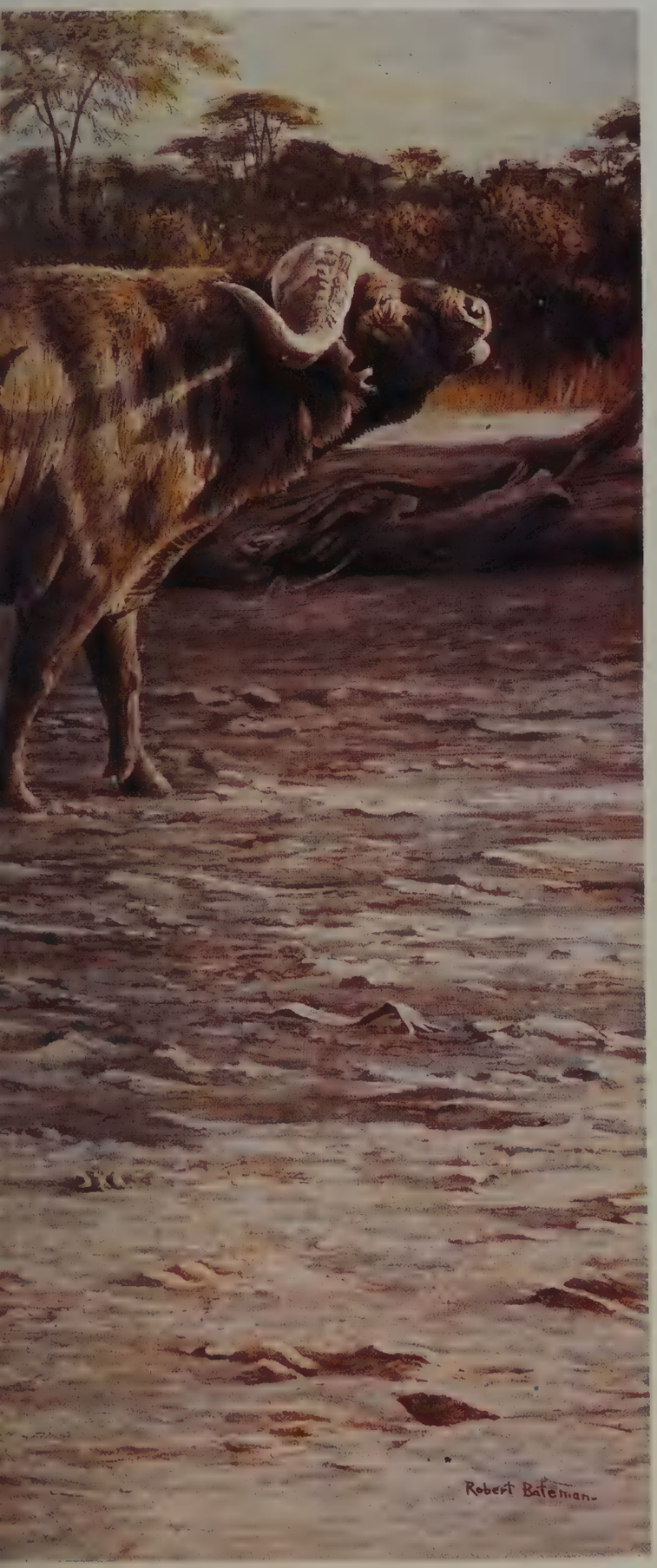
"On safari in Tanzania, I spent a lot of time peering up into trees looking for leopards—without success. They are comparatively hard animals to see in the wild—much more difficult, for instance, than lions or cheetahs—and I had never had a really good view of one. Finally, at the end of a long day, I was told where one had been sighted, and hurried to the spot. The leopard had climbed up into a tree with a fresh kill, a Thomson gazelle.

The leopard was still too tired to eat, for the gazelle that he had just hunted down and dragged up into the tree must have weighed almost as much as he did. He just lay there watching me, with only a slight sense of nervousness and tension.

When I came to paint the picture, I didn't portray any gore, but you can see the stickiness around the throat of the gazelle where the leopard has strangled it. Even in death, the Thomson gazelle seemed a delicate and lovely creature. As I worked on the painting, the drooping shape and broken limbs of the gazelle interested me, and I echoed them in the drooping, broken branch of the tree. I wanted the power of the painting to come from the big, white elemental shapes, and I placed the leafy branches in a circular arrangement to keep the viewer's eye moving around the whole format."

BUFFALO

"The beautiful Mount Kilimanjaro rises in the background of the setting of Buffalo at Amboseli, *but I was more interested in conveying the detail and texture of this old buffalo's own habitat—the trees, stumps, grasses, dust, and mud that surround him in the late-afternoon light. As often happens, while I was painting I found a shape that interested me and that became a theme in the picture—a sickle shape that appears in the buffalo's nostril and in his horn. This is echoed in the shadow of his horn on his flank and in another shadow on his rump, in the dry branches in the foreground, and in the mud."*



DIK-DIKS

"I have always been attracted to intimate scenes—a few square yards of seemingly ordinary field or forest floor or scrubland, which are filled with variety and complexity if you look carefully. The dik-dik painting is one of these miniature full-fledged landscapes. The scale is small because dik-diks are small, the smallest of African antelopes, only about twelve inches high. You can see the scale of the painting by the relative size of the elephant dung, a typical feature of dik-dik habitat, as are the different grasses and bushes and the volcanic rock.

Dik-diks are attractive animals to look at and to paint. They resemble tremendously condensed, high-strung racehorses. Every muscle shows, and their anatomy and bone structure seem very tight and interlocked. They are exceptionally nervous and you usually see them either in a freeze position or else springing out of sight."

SECRETARY BIRDS

"The name secretary bird came about in the nineteenth century because the plumes emerging from the back of the bird's head reminded people of male secretaries who kept their quill pens behind their ears.

Secretary birds are raptors and are unique in that they stalk their prey while walking. They stand about four feet tall with long, rather tough, scaly legs and long necks, and they strut along in a stately way looking down for their victims, mainly snakes. When a bird spots a snake it jumps and almost dances above it, trying to immobilize it, and then strikes at the back of the neck.

When I saw these birds flapping their wings and ruffling their feathers as they settled down in their nest, the long head and tail feathers blowing and flapping in the wind reminded me more of exotic warriors wearing flamboyant, ceremonial costumes. When I painted them, I was attracted by these shapes, and by the modulation and angle of the feathers protruding and fanning out and downward."

Their costumes and hair styles modeled after the fifties American "greaser" look, Japanese youths dance in territory staked out in Tokyo's Yoyogi Park. Such groups are called Wild Drivers because they own (or aspire to own) motorcycles and cars. Their dancing may seem spontaneous, but the performance is rehearsed.

Burt Glinn; Magnum Photos, Inc.

Tokyo Rock and Role

Beneath an alien exterior, teen-age dancers cultivate a Japanese soul

by C. Scott Littleton

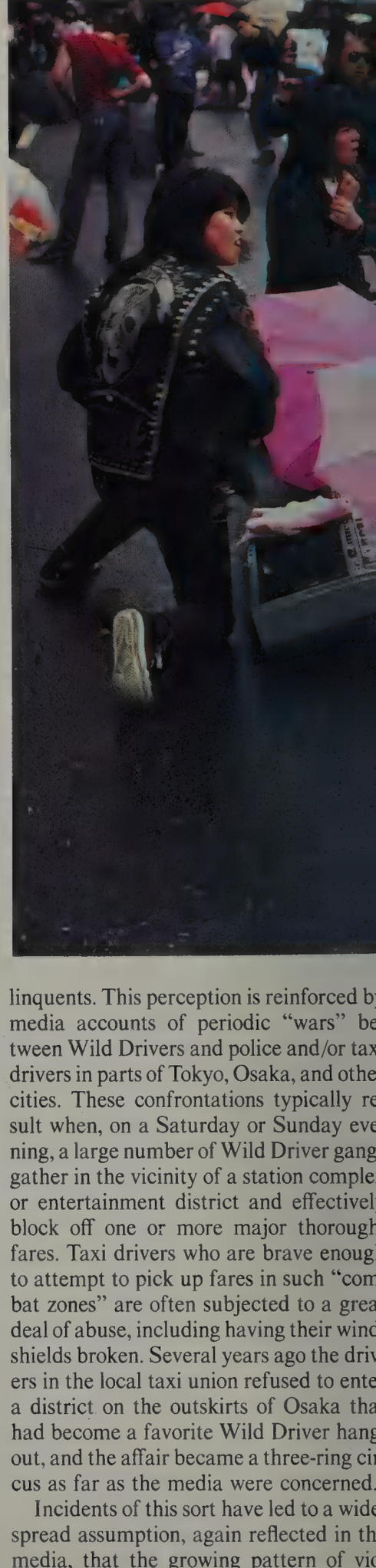
Every Sunday afternoon, weather permitting, hundreds of outrageously costumed Japanese teen-agers and young adults gather in Tokyo's Yoyogi Park to dance to tape-recorded rock music. The streets that traverse the park are closed to traffic, and a vast throng of spectators, including bemused members of the older generation, descend on the area, which is immediately adjacent to the former Olympic sports complex. Since its inception in the early spring of 1980, the Yoyogi scene has become a major tourist attraction not only for Tokyoites but also for foreigners. Tour buses now regularly include a stop at Yoyogi in their Sunday afternoon itineraries. The Japanese media, especially that portion aimed at a youthful audience, have also exploited the show. To be sure, other groups, ranging from political parties to the Japanese Hare Krishnas, also make use of Yoyogi Park on Sunday afternoons, as do a great many roller skaters, skateboarders, and high school and college drill teams, each of which occupies its own territory. But the dance groups are the main attraction.

The Yoyogi scene is not as chaotic as it might seem at first glance. The dancers are divided into small groups, ranging in size from five or six to twenty-five or thirty people. Each group supplies its own stereo tape deck and stakes out a territory within the confines of the park. These territories are jealously guarded, and the same groups tend to return week after week to the same locations. The local authorities, who otherwise keep a low profile, have imposed a permit system, and polite but efficient policemen regularly check the groups' credentials. Thus, spontaneous, individual dancing is effectively discouraged. Even here, where nonconformity appears to reign supreme, the deeply ingrained Japanese habit of subordinating the individual to the group is sustained. The Yoyogi dancers may contrast sharply with the bland image generally projected by the dark-suited "salarymen," but they are no less organized.

In the fall of 1980, when I first observed the scene, groups were divided into two distinct and mutually exclusive *zoku*, or "tribes": the *Bōsōzoku*, or "Wild Driving

Umbrellas protecting their tape equipment, a group of girls executes a carefully choreographed dance routine. All-female Wild Driver groups represent a new development in the Yoyogi scene.

Ethan Hoffman; Archive Pictures



The members of a Wild Driver group rest between dances. The forbidding emblems on their jackets imitate those of American motorcycle gangs.

Tom Ives; Black Star

Tribe" (sometimes also referred to as the *Amegurazoku*, from the title of the film *American Graffiti*) and the *Takenokozoku*, or "Bamboo Shoot Tribe." The *Bōsōzoku* are readily identifiable by their 1950s-style clothing and hair styles—shiny black pants or jeans, pointed shoes, gang jackets, and (most often) longish, greasy hair for the boys; pastel cardigan sweaters, pleated skirts, saddle shoes, and large hair bows for the girls. They look as if they had just stepped out of a somewhat blurred print of *West Side Story*.

The *Takenokozoku*, on the other hand, take their name from a popular boutique in the exclusive Harajuku district, immediately adjoining Yoyogi Park. The boutique sells the quasi-traditional costumes that serve to identify the tribe's members. These costumes, consisting for the most part of colorful, loose-fitting robes and pantaloons, are highly individualized and unisex in design. They are frequently complemented by elaborate facial makeup. The resultant image is neither Western nor exclusively Japanese; instead, what emerges is a kind of generalized Asian fantasy that, like all fantasies, is theatrical in feeling. (Unlike the Wild Drivers, the Bamboo Shoots usually do not wear their distinctive clothing on the street. They bring it with them in large shopping bags, changing after they get to the park—often behind a convenient bush.)

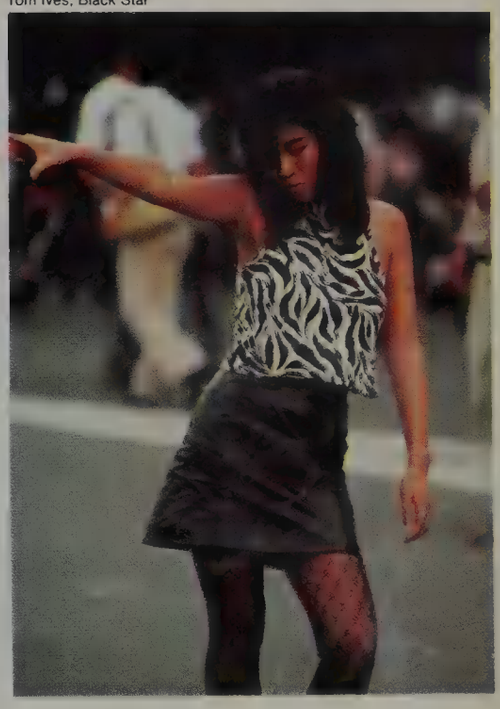
As the senior of the two tribes, both in average age and in the length of time they have been on the scene, the Wild Drivers generally occupy the more desirable locations closest to the park entrance and nearby Harajuku Station. This is in accordance with deep-rooted Japanese custom. To the best of my knowledge, the label *Bōsōzoku* first surfaced about a decade ago, and today it covers a range of groups, from innocuous dancers to antisocial gangs. All of them share a self-image derived from American motorcycle gangs and car clubs as depicted in films and on television. Most of the Wild Drivers own (or aspire to own) motorcycles, in particular, large Hondas and Kawasakis, and part of the official rationale for allowing the dance groups to use the park seems to have been to reduce the incidence of "low riding," drag racing, loitering, and other illegal activities along a nearby boulevard on Sunday afternoons. (Until recently, the Wild Drivers were exclusively male, and the female role was a subsidiary one. In the last year or so, however, several all-girl groups have surfaced, both at Yoyogi and on the streets.)

Many in the establishment see all Wild Drivers as violence-prone juvenile delinquents. This perception is reinforced b media accounts of periodic "wars" be tween Wild Drivers and police and/or tax drivers in parts of Tokyo, Osaka, and othe cities. These confrontations typically re sult when, on a Saturday or Sunday eve ning, a large number of Wild Driver gang gather in the vicinity of a station comple or entertainment district and effectivel block off one or more major thorough fares. Taxi drivers who are brave enoug to attempt to pick up fares in such "com bat zones" are often subjected to a grea deal of abuse, including having their wind shields broken. Several years ago the driv ers in the local taxi union refused to ente a district on the outskirts of Osaka tha had become a favorite Wild Driver hang out, and the affair became a three-ring ci cus as far as the media were concerned.

Incidents of this sort have led to a wide spread assumption, again reflected in th media, that the growing pattern of vio lence in junior high schools—assaults o teachers and so forth—is somehow linke to the *Bōsōzoku* phenomenon. The Wil

Although a fifties look dominates, contemporary fashions also appear at Yoyogi Park.

Tom Ives; Black Star



Drivers, who generally come from blue-collar families, are widely considered to be dropouts from the educational system, with its entrance examinations that haunt Japanese young people from kindergarten to university. (Many Japanese social scientists hold the pressures of the "examination hell" responsible for much of the current upsurge in youthful rebellion and delinquency.) The *Bōsōzoku* are also perceived as rejecting the work ethic that so pervades the mainstream Japanese mentality. They are frequently compared to the student radicals of the late sixties and early seventies, who regularly engaged in violent street demonstrations. A handful of the groups have joined forces with the radical right and its ubiquitous sound trucks, but this aspect has been blown out of proportion by the Japanese media.

The great majority of the Wild Drivers who dance at Yoyogi are not connected with the groups that have become so notorious in Osaka and elsewhere (for this reason, some of the dancers prefer the name *Amegurazoku,* but most share at least identification in name with the "hard-core" *Bōsōzoku* gangs). Save for traffic and relatively minor "status" offenses such as curfew violations, the Wild Drivers of my acquaintance have no criminal records and, for the most part, are either full-time senior high school students or are gainfully employed, albeit outside the lifetime-employment system. Apart from their costumes, many of them both look and act like typical Japanese teenagers, up to and including short haircuts (sometimes insisted upon by parents and/or school authorities). When not "on stage," as it were, they often display that thoroughly disarming, open-faced grin that one encounters so frequently among contemporary Japanese young people.

Nevertheless, the Wild Drivers' aggressive demeanor and American-inspired dance routines (Jerry Lee Lewis is a big favorite) strike the majority of adult Japanese as decidedly alien. This assessment is reinforced by the often bizarre English words and phrases emblazoned on their jackets, including names such as "Black Shadow" or "Dirty Angels" that imitate those of American street gangs. As someone from my Tokyo neighborhood saw it, the Wild Drivers have modeled themselves after the dregs of American popular culture and, in flaunting this negative life style at Yoyogi Park, have put themselves beyond the pale of respectability.

Yet these apparent outcasts, many of whom do look, at first glance, like refugees from an East Los Angeles street gang, are wholly "Japanese" in much of their behavior and deportment. Absolute group loyalty and devotion are demanded, and the interaction among group members conforms for the most part to the hierarchical pattern characteristic of Japanese society. Thus, status differences based on relative age and seniority in the group are readily apparent. Younger members defer to older members, and all concerned can be observed bowing to one another with about the same frequency as members of any comparable Japanese group, establishment or otherwise.

The dance routines, although American-inspired, are thoroughly rehearsed, and as in some traditional Japanese dances, males and females typically dance in two lines facing one another. Occasionally a couple will execute a fifties-style routine, and now and then an individual

Despite their choice of American rock music and alien costumes, Wild Drivers often dance in lines, a practice characteristic of certain traditional Japanese dances.

Rene Burri; Magnum Photos, Inc.

will perform solo. But none of these actions is truly spontaneous. Moreover, the Wild Drivers' clothing is always clean and neat, and their faces invariably seem freshly scrubbed—a far cry from those of their American role models.

The dancing and other activities are sometimes accompanied by sneering facial expressions and aggressive posturing. But these gestures are purely symbolic, and there is little if any actual violence here, even in disputes over territory. Confrontations are themselves highly ritualized. On one occasion, the Wild Drivers moved into Bamboo Shoot territory to set up a live band, and members of both tribes faced off. I witnessed the confrontation in the company of several other American spectators, one of whom remarked that if a similar situation were to arise in our culture, it would almost certainly end in a riot. On this occasion, however, after exchanging relatively mild insults, the opponents bowed to one another, and the Bamboo Shoots simply left the area. The whole arrangement had been worked out in advance with the authorities, and the leaders of the respective groups were already in agreement.

Most *Bōsōzoku* I encountered—at least the ones who dance at Yoyogi—expect eventually to become part of the mainstream, at least in some capacity. Hiroshi, for example, a crew-cut eighteen-year-old who belongs to the Dirty Angels, claims that he's never had a confrontation with either taxi drivers or the police, and I have no reason to doubt him. Like perhaps the majority of the dancers, Hiroshi and his fellow Angels, all eight of them, come to Yoyogi almost every Sunday to dance and hang out. Except possibly for some illicit street racing (all but one of them own bikes), this seems to be the limit of their participation in the *Bōsōzoku* scene. Some have suggested that Wild Drivers "graduate" to membership in the *Yakuza,* the Japanese Mafia-like crime syndicate. This may be true elsewhere, but none of the dancers I came to know gave any indication that they planned such a career. Hiroshi plans to enroll in a Tokyo technical institute after he finishes high school.

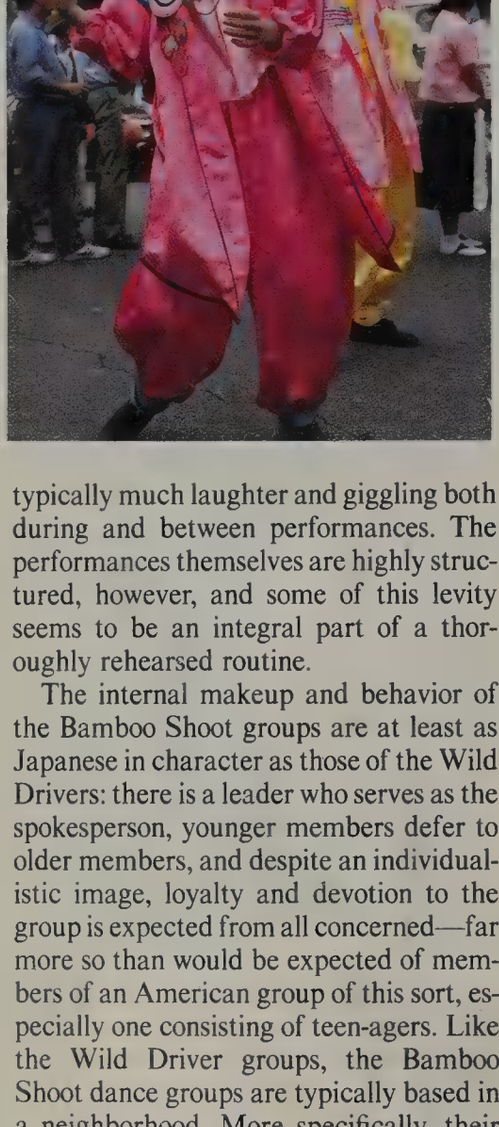
Unlike the *Bōsōzoku,* the *Takenokozoku,* or Bamboo Shoot Tribe, is composed exclusively of middle and high school students under the age of eighteen. In their demeanor, the Bamboo Shoots generally have an aura of what can best be described as amiable ecstasy. Their facial expressions are animated, in contrast to the masklike expressions usually worn by Japanese in public places or the grimaces affected by the Wild Drivers. There is

The hair style, glasses, and string tie of the male half of a Wild Driver couple recall the look of the late American rock star Buddy Holly. The girl, like most associated with the Wild Driving "tribe," affects a feminine look reminiscent of the fifties.

Tom Ives; Black Star

Ecstatic expressions are typical of the Bamboo Shoots, a tribe of boys and girls who, along with the Wild Drivers, dance in Yoyogi Park.

Hidefumi Kawada



The Bamboo Shoots prefer Asian-inspired costumes and Japanese rock music. Their name is taken from a popular boutique that sells unisex clothing.

Rene Burri; Magnum Photos, Inc.

typically much laughter and giggling both during and between performances. The performances themselves are highly structured, however, and some of this levity seems to be an integral part of a thoroughly rehearsed routine.

The internal makeup and behavior of the Bamboo Shoot groups are at least as Japanese in character as those of the Wild Drivers: there is a leader who serves as the spokesperson, younger members defer to older members, and despite an individualistic image, loyalty and devotion to the group is expected from all concerned—far more so than would be expected of members of an American group of this sort, especially one consisting of teen-agers. Like the Wild Driver groups, the Bamboo Shoot dance groups are typically based in a neighborhood. More specifically, their members may come from a particular middle school. One Bamboo Shoot girl, for example, told me that she and her friends had known one another since grammar school, and that they just naturally came together when the fad began.

The Bamboo Shoot groups usually dance in a circle, males and females intermingled, and their hand movements are graceful rather than jerky. There is a softness here, expressed in the billowing robes and smiling, heavily made-up faces, that contrasts with the *macho* image projected by the Wild Drivers. The routines are much more carefully choreographed, and the whole effect is extremely balletic. Instead of the fifties American rock favored by the Wild Drivers, the music is for the most part indigenous Japanese rock, typified by the sound of the Yellow Magic Orchestra, which has appeared on stage dressed in *Takenoko* style.

The journalist Ian Buruma, a cogent commentator on the contemporary Japanese scene, suggests that the Bamboo Shoots, who generally seem to come from middle-class "salaryman" families, are hypertraditionalists and that their overall image is consciously derived from ancient Japanese prototypes. Their dance style is reminiscent of traditional Japanese dances—except for the animated facial expressions and relaxed attitude of the dancers. Moreover, the heavily ritualized preperformance behavior, in which the leader delivers a short speech exhorting his or her fellow Bamboo Shoots to give a good performance and to uphold the honor of the group, after which all bow and clap their hands several times, recalls the sort of behavior one might expect to see at a neighborhood Shinto shrine festival. The attention to details of costuming and performance, and the long hours spent in rehearsal, are equivalent to what is required by any traditional Japanese ceremony or discipline.

But the end result is by no means wholly Japanese. Western elements appear in the individualized costumes and animated behavior of the dancers, as well as in the basic style, if not the immediate source of their music. One is sometimes reminded of the flower children of the late sixties

The generalized Asian fantasy projected by the Bamboo Shoots often includes heavy makeup. This boy's appearance is a reminder that in the seventeenth century, outrageously costumed youth—some impersonating females—helped inspire the creation of Japan's Kabuki theater.

Hidefumi Kawada

Like them, the Bamboo Shoots are consciously rejecting, at least in the context of their dances, the mainstream mode—in this case the formality, stiffness, and lack of individuality that generally characterize contemporary Japanese society.

The Yoyogi scene has precedents in the history of Japanese popular culture. For example, in the early seventeenth century, at the beginning of the Tokugawa era, groups of youths, garbed in what was then considered outlandish clothing, were wont to gather in teahouses, gardens, and other public places in Edo (present-day Tokyo) and dance or otherwise carry on in ways that outraged the sensibilities of the Tokugawa establishment. Such persons, generally the sons of merchants and lower-ranked samurai, were referred to as *Kabukishu* (from the verb *kabuku*, "to behave outrageously"), and as in the case of the *Bōsōzoku* and the *Takenokozoku*, their antics were eventually confined to certain specific locations. The *Kabukishu* style was copied—and then modified—by professional actors, who turned it into a true art form that came to be called the Kabuki theater. Unlike the older, more aristocratic No drama, Kabuki, with its lavish sets, exaggerated acting style, and "outrageous" dances and costumes, appealed to the same segment of society that had given rise to the *Kabukishu*. It even kept intact the latter's penchant for female impersonation, in the now-classic tradition of the *onnagata*, or male actor who plays female parts.

This is not to imply that the behavior of either the *Takenokozoku* or the *Bōsōzoku* will ever achieve social acceptance as an art form. The great majority of *zoku*, past and present, are ephemeral. A generation ago it was the *Taiyōzoku*, or "Sun Tribe," whose members wore Hawaiian shirts and dark sunglasses, that outraged social critics. The Bamboo Shoot phenomenon already seems to be well on the wane. The Wild Drivers are still going strong, but small groups of break dancers have already begun to make their appearance, and other embryonic *zoku*, including what the Japanese have come to call the *Punku*, or "Punkers," are waiting in the wings, as it were, to do their own thing at Yoyogi and elsewhere.

Another precedent in Japanese culture is the neighborhood Shinto shrine festival, or *matsuri*, wherein groups of ecstatic, albeit well-organized, young people bob and weave in unison as they carry portable shrines. The line between conformity and rebellion can become thin in such traditional religious performances, especially as the beer and sake flow. Among the more notorious examples of festivals gone wild were the *matsuri* associated with the *Eijanaika*, or "Who Cares about Anything?" movement of 1866, when inebriated youthful adherents danced themselves into a frenzy and then ran through the streets of Edo shouting the movement's slogan at the top of their lungs (a more literal translation is, "Isn't it all right?").

Like the *Kabukishu* before them, and the *zoku* of modern times, the devotees of *Eijanaika* were not at war with the social system per se. Although Japan was on the threshold of economic and political changes that would wrench it into the modern world, the short-lived *Eijanaika* movement had little if anything to do with bringing those changes to pass. It was instead simply one of the many rituals of rebellion that have long been a feature of Japanese popular and religious culture.

The phrase "ritual of rebellion" was coined thirty years ago by the late South African anthropologist Max Gluckman, in a celebrated essay on African religion. He identified a category of behavior in which the participants "openly state their resentment of authority" and generally act in a fashion contrary to the norms and expectations of their society, but which challenges not the established sacred tradition but rather the distribution of power within it. Gluckman also wrote of what he called a "repetitive" social system, that is, a system in which "particular conflicts are settled not by alterations in the order of offices, but by changes in the persons occupying those offices." Both these concepts apply well to Japan.

In contrast to most other highly developed, postindustrial societies, the Japanese have clung tenaciously to a repetitive system. To be sure, a great many far-reaching political and economic changes occurred at the time of the Meiji Restoration of 1868. In the space of less than a generation, the emperor was made the central focus of political authority, a Western-style parliament and constitution were introduced, and industrialization began. But even that important event, from which the modern history of Japan is conventionally dated, was not a true revolution in the Western sense but rather an extensive reshuffling of persons and roles within essentially the same ruling class.

The overwhelming majority of Japanese share a long-standing confidence in the validity and essential correctness of their social system. That view is implicitly shared by the *Bōsōzoku* and the *Takenokozoku*, just as it was by the earlier *zoku*, even though their performances are perceived (and conceived) as countercultural. As a result, the Yoyogi scene is by no means as inherently critical of the dominant culture as its Western analogs—certain rock concerts, the streets of Berkeley, the Rembrandtsplein in Amsterdam—have sometimes proved to be. On the contrary. By projecting a rebellious and/or "un-Japanese" image in an otherwise thoroughly Japanese way, the dance groups pay homage to the vitality of the social system that produced them. □

laborate preparation is reflected in a Vild Driver group's Elvis imitation. The ttention to details and the long hours of ehearsal are equivalent to what is equired by any traditional Japanese eremony or discipline.

k Wheeler; Black Star

A female red-necked phalarope in summer plumage
Martin W. Grosnic

Philandering Phalaropes

The male red-necked phalarope incubates the eggs and protects the young, leaving the female free to court another mate

by John D. Reynolds

Each spring, as the ice disappears from prairie sloughs and arctic ponds, flocks of phalaropes take up residence in the frigid water. These colorful shorebirds chatter intensely to each other as they twist and pivot, stabbing at insects and plankton, often spinning like tops and sending ripples spiraling outward. Occasionally, this dizzying scene of feeding activity is interrupted as one female lunges at another, using her bill as a weapon. The attacked female jumps back to yield to the aggressor, which then ushers her smaller, less brightly colored mate to a less congested part of the pond. Another breeding season has begun, and the phalaropes' unusual mating system is gearing up.

In the avian world, males are typically the more aggressive sex, defending territories and courting mates, while females lay and incubate the eggs and provide much of the care for their young. This is not always the case, however. The three species of phalarope (red and red-necked, which breed in the Arctic, and Wilson's, which breeds in interior North America) all belong to the less than one percent of bird species in which the males are entirely responsible for incubation and brood rearing. This leaves the females free to be polygamous. Interestingly, of the approximately thirty species of birds in which sex-role reversal is known to occur, fifteen are shorebirds. Even within this select group phalaropes stand out: neither sex maintains a territory at any stage of the breeding cycle.

The phalaropes' reversal of sex roles during the breeding season has long aroused the curiosity of naturalists. In 1895, Daniel Giraud Elliot, curator of zoology at what was to become the Field Museum of Natural History in Chicago, wrote of the red-necked phalarope, "Early in May it arrives at the breeding grounds, and the females commence to make love to the apparently indifferent males, using all the wiles and blandishments generally employed by one of the sterner sex (when bent on like purpose) to gain the favor and secure the affection of the object of its adoration." Such anecdotal accounts of phalarope courtship were typical of those written by nineteenth-century naturalists. Ironically, some of these people, who wrote of the birds with such affection, contributed to declines in accessible populations (such as those of the red-necked phalarope in the Scottish Outer Hebrides) by shooting adults and taking eggs for personal collections.

Early descriptions have been succeeded by detailed studies of the breeding biology of all three phalarope species. These studies have revealed the extent of role reversal in these birds: males invest nineteen days in incubation and another twelve to twenty days in rearing the brood. Females, in striking contrast, contribute only the eggs (nearly always four, sometimes three) to each reproductive effort and are capable of producing a second clutch for another mate only six days later.

My own research efforts have concentrated on the red-necked phalarope, a circumpolar species that, in the New World, winters at sea, primarily off the coast of Peru, and breeds in low arctic regions of Canada and Alaska. I spent the past three summers studying them at La Pérouse Bay, 25 miles east of Churchill, Manitoba, on the northwest coast of Hudson Bay. My study area was centered on the confluence of the Mast River and Hudson Bay. The water in this river delta, which varies from a few inches deep to just over hip wader level, flows around hundreds of small is lands within my 0.8-square-mile stud area. Depending on the year, from 75 t 175 red-necked phalaropes nest ami sedges and dwarf willows on these island and feed along the shores or in open wate courses. Nests belonging to different pair may be only four feet apart or hundreds o yards from the nearest neighbor.

At La Pérouse Bay, as with population of phalaropes elsewhere, the males' paren tal duties limit them to a maximum of on brood per season, while females may la two successive clutches for two differen males, a phenomenon termed serial poly andry. Eight percent of females at La Pé rouse Bay are polyandrous, with the res being monogamous or, in some cases, ex cluded from breeding. This percentage o polyandry is probably representative fo red-necked and red phalaropes. Polyandr still has not been documented among Wi son's phalaropes. Their breeding behavio is similar to that of the other two species however, and recent studies by Mar Colwell of the University of North Dakot suggest that polyandry probably occurs at least occasionally, in this species, too.

In all three species, the number of mal and female breeders is usually equa From the females' point of view, males ar thus a major limiting factor in reproduc tion and are a commodity worth fightin for. At La Pérouse Bay, aerial chases wit two or more female red-necked phala ropes noisily pursuing a harried male ar common. They often culminate in violen fights, with the females tumbling acros land or water in a flurry of wings and dan gling legs, jabbing each other with the bills. The combatant that gains the uppe hand in these battles frequently covers th submissive male with her outstretche

wings as she wards off the blows of the other females.

Phalaropes provide more than entertainment to those who watch their courtship antics. As the proverbial exception to the rule, they make it possible to test a number of general theories about behavioral differences between the sexes of animals. I have been particularly interested in differences between males and females in the time of arrival at the breeding grounds and in the tendency of individuals to return from one year to the next to the same breeding locations.

Studies of migratory bird species have shown that when males and females arrive at breeding grounds at different times, the territorial sex—normally the male—is the first to arrive. This is generally interpreted as a behavioral adaptation for competing with other males for territories and mates. Arriving early increases the chance of acquiring a territory, without which there is usually no chance of attracting a female. But what would one predict for the red-necked phalarope's mating system, which differs from most in that, one, females, rather than males, are the more competitive sex, and, two, they defend their mat directly, rather than through control territories?

To answer this and other questions, had to devise a way to capture the phal ropes so they could be given individual recognizable combinations of color band After trying a variety of traps and mis netting techniques, I found that the be method employed a small net on the en of a twelve-foot collapsible fishing pol After practicing on bubbles floatin downstream, I became adept at flickin the net over the birds as they swam. The

B. Lyon; Valan Photos

Left: A male phalarope stands guard over his day-old young. Although phalarope chicks are mobile and able to feed themselves within hours of hatching, most fathers care for them for the first week, leading them from one feeding spot to another and uttering warning cries when a predator approaches. Chicks are threatened by such dangers as the parasitic jaeger, below, which preys on both eggs and young.

James M. Richards

uld then be quickly banded, measured, nd released without harm.

In three out of four years (data from 981 were collected by Margaret Stalker Queen's University), more female than ale phalaropes were recorded during the rst week of spring arrival; by the time esting had begun, there were about as any males as females on the breeding rounds. Thus, despite the lack of territo- ality, females preceded males, which caught up" a few days later. Observa- ons of banded phalaropes revealed that ne majority of the birds censused daily were local breeders rather than migrants.

There is more than one explanation for why females precede males. One possibility is that females, which weigh 12 percent more than males, can more easily withstand the harsh conditions of early spring. However, in many species of monogamous sandpipers, females are slightly larger than males, yet males still arrive first to establish territories. The "body-size hypothesis" is thus weak as a general argument for sex difference in arrival times.

The key to the phalaropes' departure from this pattern probably lies in their reversed sex roles. Even without the need for a territory, females that arrive early probably maximize the number and quality of males for which they can compete. "The early bird gets the sperm," as David Lank of Queen's University put it. Males are usually snapped up by a female within a day of reaching the breeding grounds, and the scramble among females for mates leaves eligible males in short supply. Hence late-arriving females lose potential mates to females that preceded them, and some females at La Pérouse Bay are unable to obtain any mates at all. Since sequential polyandry is limited by availability of males and by the length of the breeding season, the potential for bigamy in this species is enhanced by pairing (hence arriving) as early as possible. Concurrent studies by Mark Colwell of Wilson's phalaropes in southern Saskatchewan reveal a similar pattern of females preceding males to courtship areas.

There are, of course, constraints on how early phalaropes can arrive. In particularly harsh and cold years, water may remain frozen and aquatic insects unavailable beyond the phalaropes' usual arrival time. This unpredictability of arctic springs requires that the birds be flexible. In 1983, for example, females and males appeared on the breeding grounds at the same time: this was one of the latest springs on record for the Churchill area. Ice jammed the entire river delta until early June, instead of its more usual melting time in mid-May. Forced to delay their arrival by two weeks, most of the phalaropes were already paired when I first saw them. Presumably, pair formation took place south of the region while they were waiting for the ice to clear.

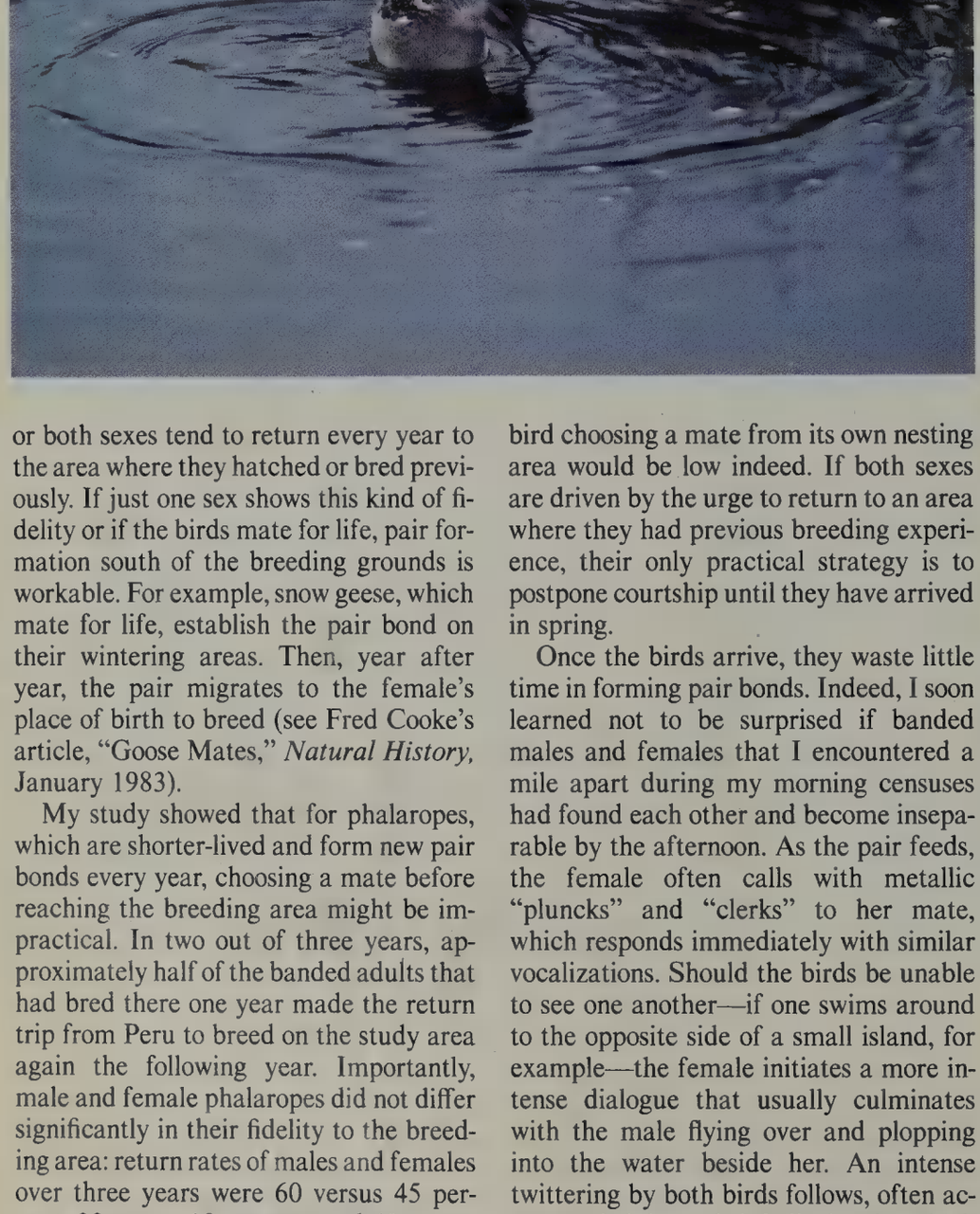
If pairing en route is possible, why don't phalaropes habitually choose their mates during migration or even on their tropical wintering areas? The answer may be that such a scheme would lead to a clash of interest if the two members of a pair had different ideas as to the best place to breed.

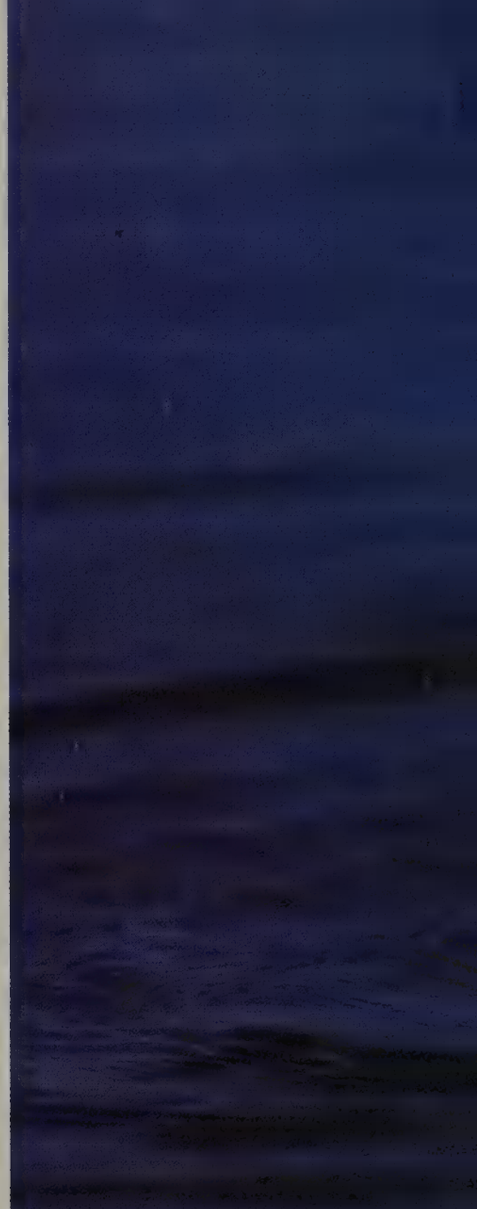
In most species of migratory birds, one

Mildred McPhee; Valan Photos

Buoyed up by a layer of down and dense breast and belly feathers, phalaropes sit lightly on the water. The birds have lobed toes, an adaptation for swimming shared by many other aquatic birds. Phalaropes, like the red-necked juvenile, below, also use their toes to help them spin around in little circles, an action that stirs up the invertebrates on which the birds feed. Wilson's phalaropes, right, have been clocked at sixty spins a minute.

R.P. Sheridan





or both sexes tend to return every year to the area where they hatched or bred previously. If just one sex shows this kind of fidelity or if the birds mate for life, pair formation south of the breeding grounds is workable. For example, snow geese, which mate for life, establish the pair bond on their wintering areas. Then, year after year, the pair migrates to the female's place of birth to breed (see Fred Cooke's article, "Goose Mates," *Natural History,* January 1983).

My study showed that for phalaropes, which are shorter-lived and form new pair bonds every year, choosing a mate before reaching the breeding area might be impractical. In two out of three years, approximately half of the banded adults that had bred there one year made the return trip from Peru to breed on the study area again the following year. Importantly, male and female phalaropes did not differ significantly in their fidelity to the breeding area: return rates of males and females over three years were 60 versus 45 percent, 20 versus 18 percent, and 43 versus 61 percent, respectively. Furthermore, both sexes tended to nest in the same particular parts of the river delta from one year to the next. Since phalaropes winter and migrate in flocks that may number into the thousands, the odds of a migrating bird choosing a mate from its own nesting area would be low indeed. If both sexes are driven by the urge to return to an area where they had previous breeding experience, their only practical strategy is to postpone courtship until they have arrived in spring.

Once the birds arrive, they waste little time in forming pair bonds. Indeed, I soon learned not to be surprised if banded males and females that I encountered a mile apart during my morning censuses had found each other and become inseparable by the afternoon. As the pair feeds, the female often calls with metallic "pluncks" and "clerks" to her mate, which responds immediately with similar vocalizations. Should the birds be unable to see one another—if one swims around to the opposite side of a small island, for example—the female initiates a more intense dialogue that usually culminates with the male flying over and plopping into the water beside her. An intense twittering by both birds follows, often accompanied by a brief display in which they lower their heads and aim their needlelike bills at each other. When this display is followed by a sharp jab by the female and a loud protest by the male, I can't help translating the female's side of the confrontation as "Stay in sight or else!" Lacking a territory, the female ca not enforce a large buffer zone around h mate, so guarding him closely is essenti for defending him from other females.

From one to two weeks after pair form tion, the male red-necked phalarope us his feet to scrape out a shallow nest on t ground near a pond or stream. The ne may be fairly exposed or set in a tussock sedge amid low shrubs. The female la one egg daily until the clutch is co pleted. At the time of each egg laying, t male performs a distinctive ritual. Stan ing a few inches to half a yard from t nest, often just at the water's edge, flicks small leaves and grasses over h shoulder with his bill, roughly toward t nest. I have counted up to sixty-two these tosses in a minute, and the proc dure may continue for the entire five to f teen minutes required by the female to l the egg. Sometimes the male mecha cally goes through the motions without a tually picking anything up. Many oth shorebirds and other ground-nesting bir

xhibit this "sideways-throwing" behavor, and in some species it has a clear funcion in lining the nest. If that is its prinipal function in phalaropes, it certainly eems inefficient! I suspect it serves prinarily as a nesting display.

During the egg-laying period, the males evelop brood patches—two oval patches f bare skin on either side of the breast hat are used to apply heat directly to the ggs during incubation. Males dutifully egin sitting on the eggs after the third or ourth one has been laid. If the nest escapes the attention of predators such as erring gulls, arctic and red foxes, weaels, and even, rarely, polar bears, the eggs atch nineteen days later. Within a few ours of hatching, the chicks, whose legs re almost as long as those of adults, can otter around and feed themselves. Most nales are attentive fathers, brooding oung regularly during the first week, givng vocal instructions to come to him or ide, and leading them from one island to nother to find safe feeding locations.

Not all males are so attentive, however. Their tendency to return from year to year allowed me to become well acquainted with some individuals, and one of the males banded in 1983 seemed to be the epitome of a poor parent. Instead of paying constant attention to his young and giving alarm calls when I approached, he seemed oblivious to both them and me. Frequently, I found his brood with no sign of him anywhere. But much to my surprise, he was one of the only males to raise all four of his young to the flying stage that year. Usually, broods lose at least one chick to predators, such as parasitic jaegers—souped-up relatives of gulls, which work in pairs, cruising slowly over the meadows, scanning for young phalaropes and other birds. The following year the same male nested only forty yards from his previous site and behaved exactly the same way, apparently ignoring his young. Once again he successfully reared them all (in this case his mate had provided only three eggs). This consistency of behavior and its apparent success forced me to wonder just what I knew about being a good phalarope parent, anyway.

For the female phalarope, the question of being a good parent does not even arise. After the eggs are laid, she completely ignores the nest and her former mate. At La Pérouse Bay some females disappear immediately after laying the eggs, presumably traveling along the coast of Hudson Bay to molt and feed in preparation for their southward migration. Others stay, share small home ranges with other females, and spend a great deal of time harassing incubating males. In a typical encounter, a female swims up to the shore of a small island and approaches a male (not her own) sitting on a nest. The male flies toward her, making a distinctive squeaking sound and twisting in the air as he lunges at her with his bill. The female retreats, and the male zigzags through the air as if in only partial control of his steering. Sometimes, he dives suddenly into the vegetation. The female resolutely flies or swims to him again, and the whole sequence is repeated. I have seen males beset by as many as eight females at once!

My initial thought—somehow attractive in its gruesomeness—to explain this harassment was that the females were attempting to destroy eggs incubated by males other than their own. This would make the males available to mate with them. Such behavior is not unknown among birds: Donald Jenni and Martyn Stephens observed just such destructive behavior in polyandrous jaçanas in Costa Rica. The females mated with the newly available males. I have no direct evidence of infanticide ("ovicide"?) by female phalaropes, although the ultimate goal of obtaining mates probably still applies. Females seem to ignore the nests, even though males often leave them unprotected as they hide or retreat. The most persistent females pursue males into the vegetation, walking slowly through the tall sedges and craning their necks as they peer around. Sometimes a male may wait for half an hour until the females have lost interest. Then he torpedoes through the water to his nest, with his body half submerged.

This arctic pond, dotted with small islands, is typical nesting habitat for the red-necked phalarope. The red phalarope also nests in the Arctic, while Wilson's—like the male at right—breeds in the wetlands of central and western North America.

James M. Richards

The males' attempts to dissuade the females' overtures are usually successful. When incubation *is* disrupted and new pair bonds formed subsequently, predation is generally the cause. Once a nest has been robbed, the male may be picked up for a renesting attempt within one day, sometimes by a female with another male caring for her first clutch elsewhere.

Much is known about the breeding biology of phalaropes, but the evolution of their mating system remains somewhat of a mystery. Shorebirds as a group seem to have cornered the market on role reversal, with about half of the avian cases occurring in this suborder. Even monogamous shorebirds possess several characteristics that preadapt them toward sex-role reversal, and it seems likely that the phalaropes' ancestors displayed these.

The first preadaptation is the widespread tendency of male shorebirds to share half the incubation duties and provide all or nearly all care of the young. Since the young are precocial, that is, they are highly mobile and can feed themselves within hours of hatching, parents do not need to provide as much care as in many other avian groups, and uniparental care can evolve more easily.

Another attribute of shorebirds that may lower the threshold for the evolution of sex-role reversal is their fixed clutch size. In many species of birds, females can increase the number of eggs laid per nest if food conditions are favorable. The invariant clutch size of shorebirds, however, means the female's best option for capitalizing on abundant food resources is to make a fresh start with a new nest, leaving the first in the care of the male.

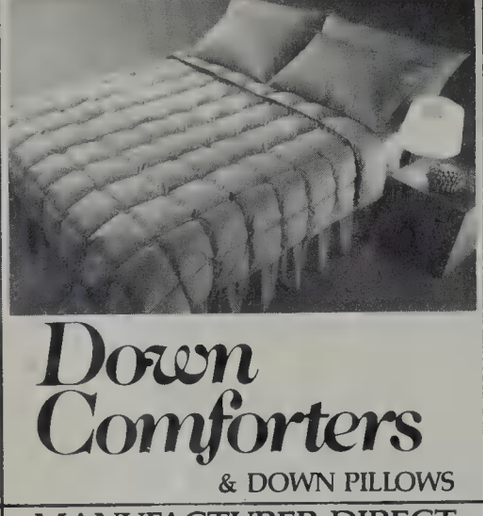
Armed with these considerations and a comprehensive review of shorebird mating systems, James Erckmann of the University of Washington concluded that when reproductive efforts and potential for further mating opportunities are essentially equal between the sexes, male uniparental care and sex-role reversal may be as likely to evolve as female uniparental care. There is no a priori reason to think that females are less likely than males to exploit opportunities for maximizing their reproductive output.

In the case of the phalaropes, the nature of the food supply may have played a key role in the evolution of role reversal and lack of territoriality. The aquatic invertebrates that form the bulk of their diet often occur in ephemeral bursts. On small ponds along the coast of Hudson Bay, for example, clusters of emerging midges and other aquatic insects occasionally gather on the water's surface in densities sufficient to attract phalaropes from one or two miles away. A few days later these ponds may be vacant while others provide an invertebrate feast. Thus, establishing and defending territories may usually be impractical for phalaropes. In especially good years, the females' freedom from incubation may permit them to exploit food resources and compete for additional mates.

What about the phalarope's appearance? The reversal of plumage coloration and size dimorphism can probably be ascribed safely to the evolutionary process Darwin termed sexual selection. This operates on characteristics that help organisms obtain mates but are of little value, or possibly even disadvantageous, in day-to-day survival. Brighter and bigger females may simply be more successful in attracting and winning mates. (Dull plumage in males, on the other hand, probably evolved through natural selection; crypti coloring should be advantageous durin incubation.)

Sexual selection is not limited to phys cal traits. Indeed, it is also the basis of th argument for why females precede male to courtship areas in spring: females ma enhance their ability to win mates b maximizing the length of time they spen competing for them. Animals with mor conventional mating systems, in whic males compete for females, are under sim ilar pressures, but in these species, sexu selection acts more strongly on males.

Studies of phalaropes are sheddin light on the relationships between soci systems and behavioral differences b tween the sexes, but challenging que tions remain. We don't know, for exam ple, the precise mix of ecological an historic circumstances that leads to th evolution of sex-role reversal. And sinc female phalaropes readily lay tw clutches but are limited by availability mates, why not incubate the secon clutch themselves, as is done by a fe other species of shorebirds? This wou double their annual reproductive outpu As we tackle these questions, we a learning not only about phalaropes b also about some of the ground rules th govern behavioral ecology in general.



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Last Chance for the Ivorybill

by Lester L. Short

Cuba is an island republic off-limits for the moment to Americans other than journalists and those conducting scientific research. It is the home of twenty-one endemic species of birds, many of which are little known. Among them is the world's last ivory-billed woodpecker (*Campephilus principalis*). One of its endemic species is the spectacularly patterned Cuban green woodpecker (*Xiphidiopicus percussus*). Having studied woodpeckers for several decades and written a monograph titled *Woodpeckers of the World*, I had observed at least one species of all twenty-six genera of woodpeckers but one—*Xiphidiopicus*, the genus composed solely of the Cuban green woodpecker. Neither had I seen the ivorybill. I was therefore delighted when, in August 1984, I received a telephone call from Comandante Universo Sánchez Alvarez, director of Cuba's Bureau of Flora, Fauna, and Protected Areas, inviting me to help search for and study the ivory-billed woodpecker.

After accepting the invitation, I requested that George Reynard, a bioacoustician who has visited Cuba six times and is preparing phonograph records on the songs of Cuban birds, be allowed to join me. This proposal was accepted by the Cuban authorities.

To get to Cuba we first had to pick up a Cuban visa in Montreal, which we did in mid-February. Then we flew from Toronto to Varadero, a peninsula of beaches and resorts on Cuba's north coast, seventy-five miles east of Havana.

Because Cuba's leading ornithologist, Orlando Garrido (a former tennis player of Wimbledon caliber), was out of the country, we were assigned a knowledgeable young biologist, Giraldo Alayón, a specialist in both spiders and birds, who heads a team surveying bird populations in western Havana Province. We laid plans for our studies, and early on February 20 the three of us flew to Guantánamo, some 600 miles farther east.

Aided by Misael Fernandez, local chief of the Cuban Institute of the Friendship o Peoples, which smooths the way for all for eign visitors, we visited the Zoologica d Piedra, a "zoo" of thirty-five, larger-than life rock carvings of animals, all in actio poses, sculpted by Angel Iñigo. Thes works are scattered about a wooded ravin full of birds. Here we observed and re corded the voices of several species, givin special attention to the West Indian red bellied woodpecker and the local race o the northern flicker. (The latter, unlike it continental relatives, feeds largely in tree and only occasionally hops about on th ground.)

One of the notable facts about Cuba birds is the great number of North Amer can wood warblers that winter on the is land (that is, they spend most of the yea from September to April, in Cuba but d not breed there). In pineland habitats, fo instance, half the birds to be seen are fa miliar North American warblers—espe cially palm, black-throated blue, prairie Cape May, black-and-white, redstart and common yellow-throats. We ident fied as many as fourteen species of wa blers in a single day (including the en demic Cuban Oriente warbler and th olive-capped warbler). Cuba, more tha 700 miles long, is the largest island in th West Indies and must be considered a ma jor wintering area essential to the long term survival of species with somewhat re stricted North American ranges, o habitats, such as the black-throated blue Cape May, and prairie warblers. Fortu nately, woodlands now occupy 12 percen more of Cuba than they did in the 1950

With the assistance of the district fo estry chief, Heriberto Ramirez, and h staff, especially Emilio Diaz and Rey naldo Balón, who were with us throughou our fieldwork, we proceeded to Mont Cristo, a forestry base, and beyond it, ove badly rutted, wet roads, eventually to Cu peyal, a fifty-five-square-mile nature re serve established in 1962. En route to Cu peyal we began to see and appreciate th

ffects of the wholesale logging that took ace between 1956 (when the area was sited by George R. Lamb, who pubshed a report on the ivorybill in Cuba) nd the 1959 revolution. Tracks that once erved as roads had been carved everyhere. Often they ran straight up and own hills and were rutted into ravines; ome had crevices ten feet deep. In addion, the clear-cutting of forests allowed unoff from frequent rains to wash away nuch topsoil. Thus, plantings of Cuban ines (*Pinus cubensis*) under the present overnment's reforestation program have ot grown as well as they might have—a actor possibly of crucial significance to he survival of the ivorybill. (Can the bird urvive until the trees are suitably mature o provide more extensive habitat?) Large reas of young, diversely aged plantings, ostered by foresters at many plantations, re mixed with a tangle of cutover hardvoods, junglelike in aspect.

We centered our search to the east and outh of the Cupeyal reserve in rough country with steep hills and rocky outcrops. Wetter slopes and lower areas near streams were covered either with second-growth deciduous forest and a dense understory or with head-high thickets of ferns and bushes. Drier slopes bore pine stands of various ages. We walked nine to twelve miles a day, despite frequent rain showers, searching for signs of the ivorybill. In particular we looked for big trees (of which there were few) and for the workings of the woodpecker, which feeds by scaling bark from freshly dead trees to obtain beetle larvae and other wood-boring insects. I chanced upon such workings near the Cupeyal House, in an area where the ivorybill had last been seen in 1976. At least three pine trees had been stripped of most of their bark within the previous few months, as evidenced by the fresh condition of the underlying wood and quite in contrast with the other gray, dead trees scattered about. Beneath the recently stripped trees were bits of fresh, white wood and pieces of bark two to six inches wide and four to eight inches long. These bits of evidence closely resembled the workings left by the pileated woodpecker, the continental North American species that at times scales bark like the ivorybill. There are no pileated woodpeckers in Cuba, and the other four resident woodpeckers (the Cuban green and West Indian red-bellied woodpeckers, and the two flickers, the northern and Fernandina's, all much smaller, weaker-billed woodpeckers) are incapable of stripping a tree in this way. Yellow-bellied sapsuckers from North America winter in Cuba, but they, too, are small and do not scale bark.

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The ivory-billed woodpecker, as depicted by pioneer American ornithologist Alexander Wilson

For four days in late February we sought the ivorybill in the area of pine workings, and in the surrounding mixed pinewoods, deciduous woods, and scrub, with no success. We concluded that a lone ivorybill had passed through the area sometime in the past half year, but that it was no longer in the vicinity.

Word of our search having passed

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through the surrounding countryside, we found at our door one morning an old woodsman on a horse. He introduced himself as Felipe Montero Rodriguez, a longtime resident who, for some three decades, had been involved in forestry work in the region. He related the history of the ivorybill to us; namely, that it had been uncommon but present in the 1950s and had become increasingly rare in the 1960s and 1970s. Before December 1984, he had last seen one in 1977. On December 15 or 16, 1984, while walking in an area of fairly large, twenty-year-old pines, he had heard the pounding of a woodpecker on a tree. He described to us the bird that he observed for five minutes as *cao*-sized (the local crow, *Corvus nasicus*, which is ivorybill size), black and white, and crested, without red on the head (thus a female ivorybill). The site was some five miles south of us, and we moved our base to a working forestry nursery station at La Munición, near Sr. Montero's site of observation, a hill overlooking a steep, well-wooded valley. We reached the site nearly at dark on March 1, 1985. Here we heard the calls of a stygian owl, an uncommon tropical American owl that is potentially large enough to prey on an ivorybill. But we found no signs of the woodpecker that night or on the ensuing three days—all that were left to us before we had to return to Havana. On the morning of March 2, we did, however, discover a nest of the rare, endemic Gundlach's hawk, a bird-eating hawk related to, but larger than, the Cooper's hawk of North America. George Reynard heard the screechy calls, taped them, and found the nest of the hawk in a tall pine tree (the nest of a Gundlach's hawk had never been photographed nor the eggs and nest adequately described). We worried about finding the owl and pair of large hawks within 150 feet of where Sr. Montero had reported the ivorybill. We again concluded that no ivorybill was currently in that area.

Back in Havana on March 7 and 8, we discussed the situation with Cuban authorities and particularly with Dr. Garrido, just back from a meeting in Peru. Garrido is convinced that wilder, almost inaccessible land east and southeast of where we had worked will prove to have pockets of pines and other trees, of greater breadth and height than those we had observed, that could harbor ivorybills. Indeed, a pair had been reported in an isolated valley southeast of the Sierra de Moa, during the late 1970s. This information, along with our finding and Montero's report, convinced me that at least several lone ivorybills, and quite likely a few pairs, exist in the region between Cupeyal, the southern Sierra de Moa, and the Sierra de Purial to the southeast.

When I arrived back in New York, I submitted to my Cuban colleagues a plan for aircraft and ground searches by teams of forestry and ornithology specialists to locate areas of suitable or potentially suitable ivorybill habitat, if not the birds themselves. If these searches are carried out, I hope to return to Cuba in April 1986 (when all ivorybills ought to be paired and nesting or, if solitary, presumably located in suitable nesting habitat), either to help find the birds or to study them if they are located before then. A letter from Sr. Alayón in May stated that my plan was indeed being implemented; a team is going to La Melba this summer. I am convinced that only in Cuba is there any chance of the continued existence and possible buildup of a viable population of the ivorybill, a magnificent woodpecker that surely is one of the most endangered species of birds in the world. Given today's political climate it is ironic to think that, just possibly, Cuba and the United States may someday cooperate in the reintroduction of the ivorybill to North America!

Lester L. Short is chairman of the American Museum's Ornithology Department.

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The Dream Is Alive is now being shown on the giant, four-story screen of the Museum's Naturemax Theater. This new, large-format film about the space shuttle features breathtaking views from space filmed aboard the spacecraft. The astronauts, who say the views of the earth and moon in the film are the "closest thing to being there," carried the special, eighty-pound camera with them on several shuttle flights. The camera uses film that is ten times larger than 35-mm film and three times larger than the 70-mm film used by commercial film producers. The result is a huge image whose clarity and brilliance are not achievable with a normal system. The viewer will see the astronauts at work, both inside and outside the spacecraft, as they deploy satellites, capture and repair the malfunctioning "Solar Max" satellite, and walk in space. There are even scenes of the astronauts floating in their sleeping bags. For schedule information call (212) 496-0900.

Threshold Company

The Dream Is Alive *is the newest feature at the Museum's Naturemax Theater.*

At the Hayden Planetarium

The Hayden's new, double-feature Sky Show will continue throughout the summer and fall. *Hayden: The Golden Years* explores the astronomical discoveries of the last fifty years, and *Halley's Comet: Once in a Lifetime* demonstrates where and when people can expect to see Halley's comet. For information and show times call (212) 873-8828.

Delightful Animals

The family members' program in August will be *Delightful Animals,* two films for all ages. They are *Squirrel on My Shoulder,* about a naturalist who finds a baby squirrel, which is adopted and raised by his cat, and *The Mouse's Tale,* about the life and habits of dormice in Wiltshire, England. The program will take place on Tuesday, August 13, at 11:00 A.M. in the Kaufmann Theater, and again at 7:30 P.M. in the Auditorium. It is free and only open to members; for more information, call (212) 873-1327.

Songs of the Sea

On Tuesday, August 6, at 7:30 P.M., the Membership Office will present *Songs of the Sea,* a free concert by Tom Goux and Jacek Sulanowski, who have spent the last decade researching chanteys and ballads from the heyday of the great sailing ships. The program is open only to members; advance registration is required. For information call (212) 873-1327.

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Crayfish (p. 32)

Paul Colinvaux's *Why Big Animals Are Rare* (Princeton: Princeton University Press, 1978), a cogent introduction to the basic concepts of ecology, has been praised as "an incisive and stirring book, and a model of scientific explanation" by the *New Yorker.* The book's subjects include the social lives of plants, why the sea is blue, the ocean ecosystem, the succession affair, what hunting animals do, and why there are so many species. British zoologist Charles Elton wrote many of the classic texts on animal ecology, including *The Ecology of Invasions by Animals and Plants.* Originally published in 1958, it was reprinted by Chapman and Hall in 1972 and is available in paperback. For a good introduction to the characteristics of freshwater ecosystems and the animals that dwell in them, see *Ecology of Fresh Waters,* by Brian Moss (New York: John Wiley and Sons, 1980). T.H. Huxley's *The Crayfish,* published in 1880, was reprinted by the M.I.T. Press, Cambridge, in 1974.

Yoyogi Park (p. 48)

Ian Buruma's *Behind the Mask* (New York: Pantheon Books, 1984) is a fascinating examination of Japan's popular media (films, television, plays, books, comics), traditional literature, myths, and other elements—such as sexual demons, sacred mothers, transvestites, gangsters, drifters, and cultural heroes—that shape the Japanese collective imagination and national identity. He finds that sexuality and sex roles underpin the elaborate structures of Japanese culture, and that "violent entertainment and grotesque erotica are . . . important outlets in . . . an oppressive social system." In "Japan's Outrageous Conformists" (*Asia,* July-August 1982, pp. 16–20, 54–55), Buruma shows how the rebellious behavior of the Bamboo Shoots and other supposedly nonconformist youth tribes is actually "an elaborate fake, a beautifully studied act, that only looks like the real thing." *Japanese Culture and Behavior,* edited by Takie Sugiyama Lebra and William P. Lebra (Honolulu: University of Hawaii Press, 1974), contains many fine articles, such as "Higaisha-Ishiki: The Psychology of Revolting Youth in Japan," by Takeo Doi, "Delinquent Groups and Organized Crime," by Hiroaki Iwai, "Intergenerational Continuity and Discontinuity in Moral Values among Japanese," by Takie Sugiyama Lebra, and "Japanese Value Orientations and Culture Change," by William Caudill and Harry A. Scarr. Robert C. Christopher links the "highly conformist display of nonconformity" that takes place at Yoyogi Park to the pressures of the country's grueling educational system in *The Japanese Mind* (New York: Simon and Schuster, 1983), a perceptive and entertaining book that he describes as "a psychic and institutional guidebook to today's Japan." Social anthropologist Chie Nakane presents the important element of Japanese behavior and culture, including the emphasis on group organization, in *Japanese Society* (Los Angeles: University of California Press, 1972). Edwin O. Reischauer, who grew up in Japan and was the ambassador to that country under the Kennedy administration, is one of America's most respected Japanologists. *The Japanese* (Cambridge: Harvard University Press, 1977), his overview of Japanese history, culture, character, and psychology, is a standard introduction to Japanese civilization. Finally, Max Gluckman's "Rituals of Rebellion in South-East Africa" can be found in *Order and Rebellion in Tribal Africa* (New York: The Free Press, 1963).

Paul Chesley

Yoyogi Park, Tokyo

Phalaropes (p. 58)

O. Hildén and S. Vuolanto's "Breeding Biology of the Red-necked Phalarope *Phalaropus lobatus* in Finland" (*Ornis Fennica,* vol. 49, pp. 57–85) is by far the most detailed article written on these birds. E.O. Hohn explores their reproductive strategies in "Observations on the Breeding Behaviour of Grey- and Red-necked Phalaropes" (*Ibis,* vol. 113, pp. 335–48) and the hormonal basis of their behavior in "The Phalarope" (*Scientific American,* vol. 220, pp. 104–11). For a review of "unusual" mating systems in birds, including so-called role reversal, see W.J. Erckmann's "The Evolution of Polyandry in Shorebirds: An Evaluation of Hypotheses" in *Social Behavior of Female Vertebrates,* edited by S.K. Wasser (New York: Academic Press, 1983), and Lewis W. Oring's "Avian Polyandry: A Review," in *Current Ornithology, Vol. 3,* edited by R.F. Johnston (New York: Plenum Press, due out later this year). A detailed and accurate description of the phalarope's life history, drawn from other works, is presented in *The Birds of the Western Palearctic, Vol. 3,* edited by S. Cramp and K. Simmons (Oxford: Oxford University Press, 1983).

Rita Campo

Correction On page 92 of the May 198 *Natural History,* a caption incorrectly refers to the plant in the photograph as a coconut. It is in fact a taro, perhaps the coco yam, *Colocasia esculenta,* or the swamp taro, *Cyrtosperma chamissonis.*

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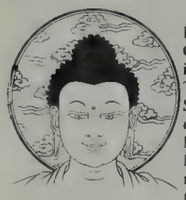

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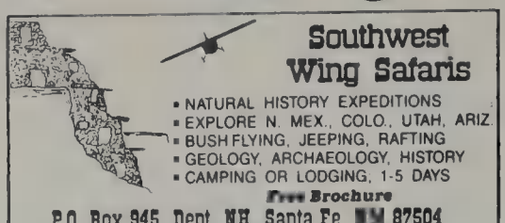
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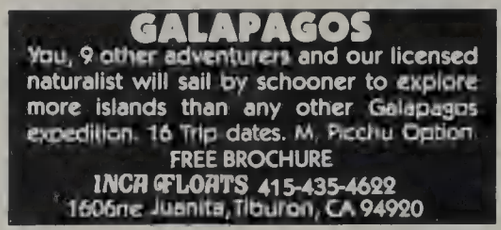
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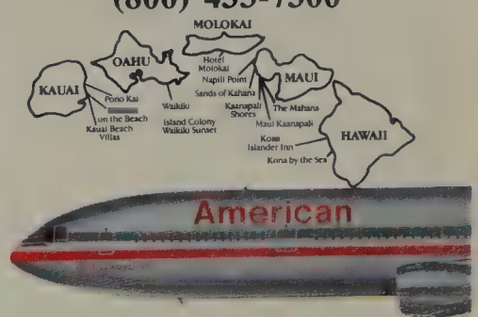

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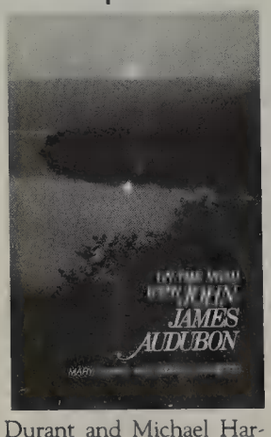

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Hot Stuff

Why has it taken half a millennium for chilies to take hold in Anglo-Saxon cultures?

by Raymond Sokolov

As you may recall from last month's outing, I have lately been concocting flavored vodkas in the Russian manner, especially pepper vodkas made fiery and flavorful by hot peppers of the genus *Capsicum* (chilies). One of the less frequently noted virtues of these sophisticated folk spirits is that they promote reflection. After their alcoholic content has induced a certain calmness, you find yourself ruminating on other aspects of these remarkable beverages besides their ability to intoxicate.

Last month I considered the paradox that pepper vodka must be served ice cold in order to taste ideally hot. This happens, it turns out, because cold slows down the release of vodka's other volatile elements more completely than it impedes the escape of the flavoring elements in the chilies and other spices that Russians typically add.

An even more fundamental question lies behind the unrecorded discovery of this phenomenon by some experimental Russian toper long ago. He could not have done what he did if he had not had access to capsicums in the first place.

The story of the transmission of these warm-weather American exotics to the landlocked icebox of Europe begins in 1492 with Columbus. You will find a detailed and scholarly account of it in Jean Andrews's new book, *Peppers: The Domesticated Capsicums* (University of Texas Press). Andrews, who has devoted many years to the study, culture, and painting of capsicums, dates the arrival of the chili in Europe to the arrival of the *Pinta* at Bayona, Spain, in 1493, an event celebrated locally on March 1. Whether Columbus actually brought chilies back with him from this first voyage is unknown. He definitely knew about ther for in his first letter to Ferdinand and Is bella and the treasurer of Aragon, wrote that the West Indian islanders e dured the cold of winter in their mou tains "with the aid of the meat they e with very hot spices."

On the assumption that Columbus to the obvious step of collecting the source these spices, Andrews made a pilgrima to Bayona in 1983 and scattered jalape seeds in the churchyard of Ex-Colegia Santa María in Bayona, where the *Pinta* crew gave thanks for their safe return most five centuries ago.

Written accounts of the chili appear after Columbus's second voyage (one m even have been written in April 149 And since a major impulse for these a later voyages of exploration was to bri exotic spices to Europe, it is not surprisi that this new "pepper" (it is entirely un lated to the black pepper, *Piper nigru* which Columbus hoped to find) w quickly spread from one end of the Spa ish and Portuguese trade routes to t other.

You might guess that with their cap cum commerce in full swing by the mid 1500s, the Iberian traders would ha been the source for the chilies that start turning up in the Slavic countries abo the same time. But this is not how it ha pened. The Portuguese did bring cap cums to India and China, through th colonies at Goa and Macao, making p sible hot Indian and Sichuan food as know it. But the first red capsicums to ter northern Europe came from the B kans, imported by the Ottoman Tur Andrews speculates that the Ottoma had latched on to chilies as early as 15 during their siege of the Portuguese c

y at Hormuz in the Persian Gulf. From
e Balkan fringe of the Ottoman Empire,
e peppers spread naturally into neigh-
ring spheres of influence, to the Ger-
an-speaking part of the Holy Roman
npire (1543) and to the vast territories
the former Byzantine Empire and to
ussia. Hungarians, in the middle of this
tteleuropäisch pepper pot, started talk-
g about paprika as early as 1569. The
agyar word *paprika* is a variation on a
avic term for pepper, *peperke, piperke,*
paparka.

Hungary was and still is the northern-
ost major producer of capsicum peppers
Europe. No doubt it is at the upper limit
the plant's range. But even Hungary
s slow to work paprika into its everyday
isine (the rest of northern Europe never
similated truly hot spices). The first two
ungarian paprika recipes did not appear
print until 1829, in Istvan Czifrai's
okbook. They were paprikas chicken
d halaszle, the fish soup of Szeged, the
nter of capsicum culture in Hungary
en and now.

When I first met George Lang in 1971,
the eve of the publication of his *The*
isine of Hungary, he served me ha-
zle (see recipe), a robust soup and an el-
ant allusion to the history of Hungarian
oking.

For Hungarians, paprika is not the
nocuous red dust we buy in supermar-
ts; it comes in several grades, from the
eet to the fiery hot. But paprika con-
isseurship is limited to ethnic Magyars
d food hobbyists, just as almost all en-
usiasm for hot capsicums used to be a
ry special predilection in this country
tside of Louisiana and regions formerly
lonized by Spain or Mexico.

In those places, there has always

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Courtesy of University of Texas Pre

Painting of Capsicum chinense *var.* rocotillo, *by Jean Andrews*

been a cult of hot peppers and hot food, but the supermacho aspects of Tex-Mex food, with its jalapeño-eating contests and four-alarm chili, confused outsiders and made them think that chilies were a crude and unreasonable condiment unrelated to the usual culinary refinements: flavor and complexity.

The same confusion muddled American appreciation of Indian food and, most recently, Sichuanese and Hunanese. Some people insisted on very hot and presumably authentic versions of these exotic cuisines. Others, unused to hot foods, sent back what they had ordered, creating difficulties and embarrassment in restaurant kitchens. Meanwhile the judgment, enjoyment, and presentation of Mexican, Indian, and Chinese food in this country was polarized into an oversimplified matter of hot or cold.

Vast inexperience of capsicums l most Americans unable to approach the new foods with an open mind. It has tak almost twenty years for the initial shock hot capsicum-based cuisines to wear and for large numbers of people to beg to get beyond the crude fact of hotness an appreciation of the diverse flavo brought to food by the many varieties chilies employed with such finesse el where.

The restaurant booms in Mexica Sichuan, and Thai food have helpe More and more people have habituat their palates to the burn of capsaicin, t chemical essence of capsicum heat. Th are now ready to pay attention to the m tiform pleasures of the myriad cultivars *Capsicum annuum*, the chili species sponsible for almost all the peppers we counter.

And we do encounter an ever greater mber, even those of us far from Santa and El Paso and the Grand Central arket in Los Angeles. There has been a eat change since I first read the section chilies in Diana Kennedy's *The Cui-es of Mexico* and wondered if I would er be able to cook most of the dishes in r book at home, since they required ar-ne chilies with names like *pasilla* and ero and *cascabel.*

I also wondered if the lady wasn't mak-g a bit of a learned fuss over chili speci-ity. Then I took a trip to the French is-nds of the Caribbean and immersed yself in the local Creole cuisine, which, nong other fetching characteristics, has ypical flavor that owes much to a crin-y, cherry-sized pepper, hot but not infer-lly so. It was crucial to the taste of the nnipresent fish stew called blaff and to any other dishes impossible to re-create home without it.

Now I can buy this pepper by the bag in y supermarket. And thanks to Jean An-ews, I can identify it. It is *C. chinense,* r. *rocotillo.* And I am happy to say that ndrews likes it too.

"After growing and tasting peppers om all over the Western Hemisphere for ve years," she writes, "my hands-down vorite 'eating pepper' is the rocotillo. his crisp textured fruit with enough pun-ency to be interesting but never caustic is t only delicious eaten raw but also beau-ful to look at when used as a garnish." *ocotillos* are either pale yellow-green or d, and they grow well in central Texas. at them on the side, as a condiment with eans or roast meat, or throw them in with l manner of foods while they cook. The *rocotillos* I am buying are pallid in flavor compared to the ones I recall from Martinique, but they are interesting and worth tasting anyway.

That we can buy *rocotillos* at all in New York is wonderful testimony to the resilience of the marketplace and to the flexibility of the consumer. But at the same time we might also ask ourselves why it has taken half a millennium for chilies to take serious hold in a culture with an Anglo-Saxon, north European base.

Why did capsicums not find a happy home north of the Pyrenees? To an extent, botany was destiny. Peppers were hard to grow in northern climates. But the Hungarian experience is proof that it can be done if the will is there.

The taste for extremely hot spices, of which capsicums are the epitome, does seem to be culturally acquired. Sichuan province already had embraced its local brown pepper before capsicums came in, and India was a proverbial center of spices. Northern Europe, on the other hand, had to import most of its spices. And capsicums seem to have presented too much of a challenge to the palate. They did not really catch on with English speakers until the current craze for regionalisms and ethnic food swept over the previously phlegmatic northern United States.

Is this a good thing? Certainly it opens new possibilities at the table. And if your tongue is burning from some new variety of hot pepper, try to remember that capsicums are an excellent source of vitamin C.

Raymond Sokolov is a writer whose special interest is the history and preparation of food.

Halaszle

(Hungarian Fisherman's Broth,
from George Lang's *The Cuisine of Hungary,* Atheneum)

1 whole live carp, 5 to 6 pounds, or a section of similar weight
Salt
3 or 4 medium-sized onions (about 1 pound), chopped fine
2 tablespoons paprika
1 green pepper, cut across in very thin slices

1. Carp should be alive when you buy it. Ask the fishmonger to bone carp, remove its skin, and cut meat in 4- or 5-inch chunks. Be sure he gives you the skin and bones. Also, make sure you purchase female carp with a lot of roe; purchase extra milt. If you buy a male fish with milt, purchase extra roe. Do not wash the inside of the fish; the blood makes the dish tasty.
2. Boil skin, bones, and head of the carp in 2 quarts water with 1 teaspoon salt for about 20 minutes. Strain the broth.
3. Cook the onions in the fish broth for about 30 minutes. Force the onions through a sieve or purée in a blender and put back in the broth.
4. In a 4-quart soup or stew kettle, place pieces of fish next to each other. Pour the onion broth over the fish. Add as much water as necessary to cover fish.
5. Bring liquid to a boil; add 1 teaspoon salt, the paprika, and green pepper. Cook for about 10 minutes. Do not stir, but shake the pot.
6. Add the roe and milt and cook for an additional 4 or 5 minutes. Let the soup stand for 5 minutes before serving.
7. Serve as a one-dish luncheon, as a late-night supper dish, or as the soup and fish courses of a dinner.

Yield: 8 to 10 servings

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A Nasty Habit of Spitting

South Africa has a number of reptile parks and one of the largest of these is Transvaal Snake Park, outside Johannesburg. Tony Bannister has visited there often in the past year and a half to take photographs for a book on African reptiles and that is how he came to take this photograph of a Mozambique spitting cobra (*Naja mossambica*).

According to the late Vivian FitzSimons, an authority on the snakes of southern Africa, this species—also known as *m'Fesi*—is one of the most dangerous on the continent. It is high-strung and is one of only a few snakes in Africa that can "spit" its venom.

If the snake perceives any threat, it will rear up as much as two thirds of its length and spit two streams of venom that can travel up to nine feet. Actually the snake squirts, rather than spits, the venom by contracting muscles that surround its poison gland. This forces the poison into a duct, according to FitzSimons, and then out through openings near the tips of the fangs. The cobra usually directs its attack toward the face or eyes of its adversary. If the venom enters the eyes, it can cause intense pain and temporary or permanent blindness.

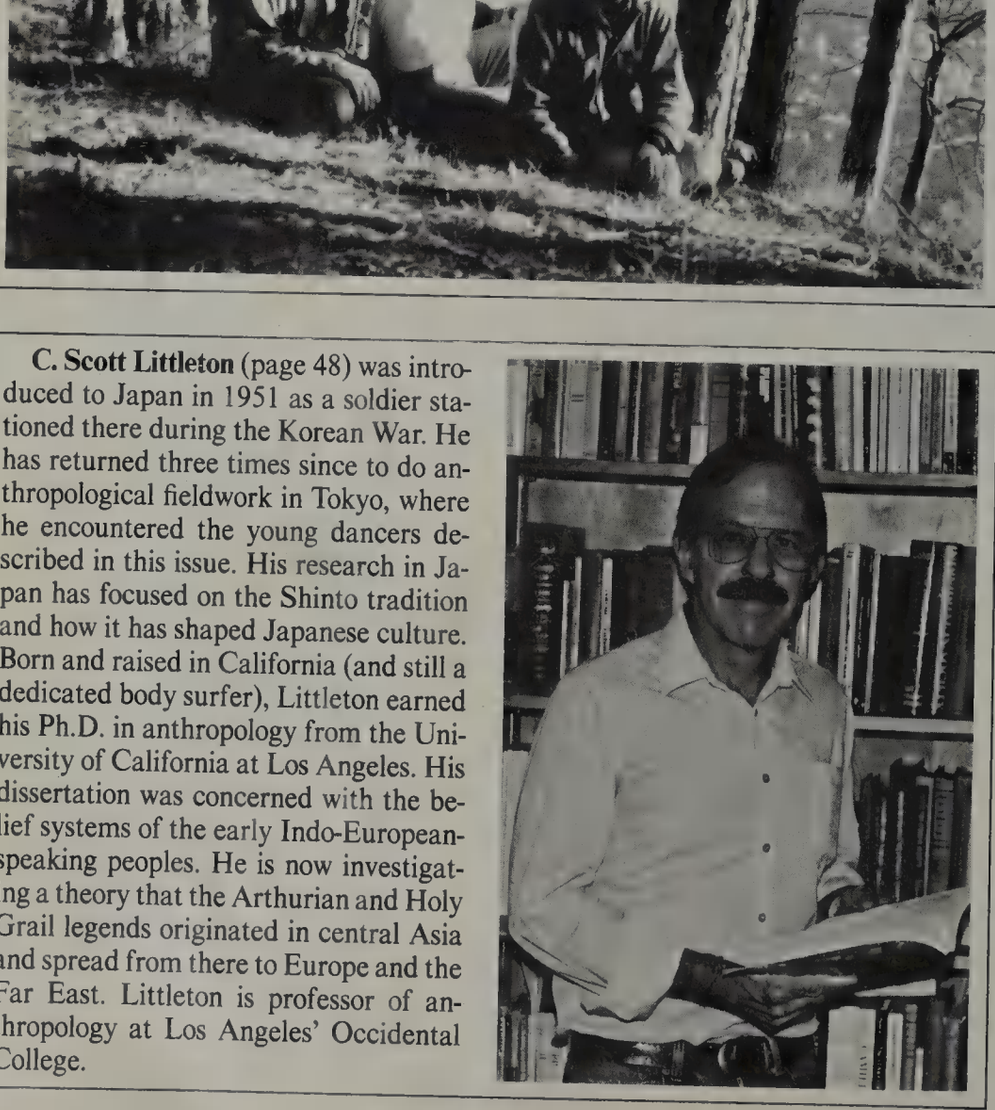
But the Mozambique spitting cobra is not an aggressive snake and usually uses its poison as a defensive tactic. Like one other African snake, the rinkals, it often feigns death rather than attempting to bite. This cobra generally eats small mammals, birds, amphibians, lizards, and bird eggs.

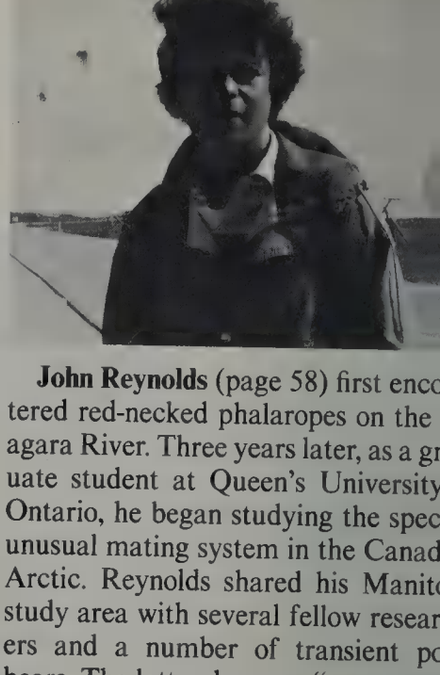
The snake in this photograph would ordinarily have sprayed Bannister, but the naturalist-photographer brought a friend along with him as a decoy. The friend distracted the cobra and promptly got soaked. Bannister, who kept his left eye closed and his right eye on the camera's viewfinder, stayed mostly dry but took a few direct hits on the lens.

Photograph by Anthony Bannister

Authors

David M. Lodge (page 32) received his doctorate in zoology from Oxford University as a Rhodes scholar. "From England," says Lodge (middle), "I was looking for a way to expand my ecological horizons and place my studies of snail populations in the broader perspectives of the ecology of communities." His research at the University of Wisconsin at Madison Center for Limnology allows him to do just that. He dives into lakes to investigate predation and herbivory and their impact on lake ecosystems. Lodge recently took up duties as an assistant professor at the University of Notre Dame. Coauthor **Annamarie L. Beckel** (left), an ecologist and writer, earned her doctoral degree in ecology and behavioral biology at the University of Minnesota. She has carried out field studies of river and sea otters and heads a pine marten captive breeding and reintroduction program. Beckel has also done her share of crayfish trapping and is now writing a book covering the hundred-year history of limnology studies at the University of Wisconsin. **John J. Magnuson** (right), a veteran fisheries biologist with an extensive background in teaching and research, has helped train many young ecologists. He is professor of zoology at the University of Wisconsin at Madison and director of the Center for Limnology. Magnuson guides many of the long-term investigations undertaken by the Center, in particular, those concerning his area of greatest expertise—fishes. When not delving into lake life, he enjoys gardening, photography, and collecting fish stamps.





John Reynolds (page 58) first enco
tered red-necked phalaropes on the
agara River. Three years later, as a gr
uate student at Queen's University
Ontario, he began studying the spec
unusual mating system in the Canad
Arctic. Reynolds shared his Manit
study area with several fellow resear
ers and a number of transient po
bears. The latter, he says, "were usua
indifferent to us but would sometim
amble over to see what the funny a
mals with binoculars and mist nets w
doing (we were beating an unequivo
retreat!)." Reynolds, currently a visit
researcher at the Boreal Institute
Northern Studies, University of
berta, is continuing his studies of
ecology and growth of young phalarop
During May and June of this year,
was in central Finland studying ruffs a
other shorebird species.

C. Scott Littleton (page 48) was introduced to Japan in 1951 as a soldier stationed there during the Korean War. He has returned three times since to do anthropological fieldwork in Tokyo, where he encountered the young dancers described in this issue. His research in Japan has focused on the Shinto tradition and how it has shaped Japanese culture. Born and raised in California (and still a dedicated body surfer), Littleton earned his Ph.D. in anthropology from the University of California at Los Angeles. His dissertation was concerned with the belief systems of the early Indo-European-speaking peoples. He is now investigating a theory that the Arthurian and Holy Grail legends originated in central Asia and spread from there to Europe and the Far East. Littleton is professor of anthropology at Los Angeles' Occidental College.

Anthony Bannister (page 78), who w
born in England but grew up in Sou
Africa, worked professionally at ele
tronics for many years and consider
photography his hobby. But travel in
adopted homeland increased his lo
and knowledge of natural history. He b
came an amateur naturalist. Callin
upon his training in electronics, he d
signed special equipment for use in ph
tography—in particular, high-spee
flashes like those Stephen Dalton deve
oped for himself in England. In 197
Bannister resolved to change careers an
took up photographic work full tim
Since then he has published seven book
and assisted in the production of sever
wildlife films. All these films have sinc
been purchased by the National Geo
graphic Society for the purpose of tele
vising them in the United States. Banni
ter, who lives outside Johannesburg,
married and has three sons and a daugh
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Vol. 94, No. 9, September 1985
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ATURAL HISTORY *(ISSN 0028-0712) is published monthly by the American Museum of Natural History, Central Park West at 79th Street, New York, N.Y. 10024. Subscriptions: $20.00 a year. In Canada and all other countries: $26.00 a year. Second-class postage paid at New York, N.Y. and at additional mailing offices. In Canada second-class postage paid at Windsor, Ontario (permit no. 9579).*

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Natural History *is indexed in* Reader's Guide to Periodical Literature.

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Bligh's Bounty

A captain who followed the rules meticulously found an animal that broke them brilliantly

by Stephen Jay Gould

In 1789, a British naval officer discovered some islands near Australia and lamented his inability to provide a good description:

> Being constantly wet, it was with the utmost difficulty I could open a book to write, and I am sensible that what I have done can only serve to point out where these lands are to be found again, and give the idea of their extent.

As he wrote these lines, Capt. William Bligh was steering a longboat with eighteen loyal crew members into the annals of human heroism at sea—via his 4,000-mile journey to Timor, accomplished without loss of a single man, and following the seizure of his ship, *The Bounty,* in history's most famous mutiny.

Bligh may have been overbearing; he surely wins no awards for insight into human psychology. But history and Charles Laughton have not treated him fairly either. Bligh was committed, meticulous, and orderly to a fault—how else, in such peril, could he have bothered to describe some scattered pieces of new Pacific real estate.

Bligh's habit of close recording yielded other benefits, including one forgotten item to science. Obsessed by the failure of his *Bounty* mission to bring Tahitian breadfruit as food for West Indian slaves, Bligh returned to Tahiti aboard the *Providence* and successfully unloaded 1,200 trees at Port Royal, Jamaica, in 1793 (his ship was described as a floating forest). En route, he stopped in Australia and had an interesting meal.

George Tobin, one of Bligh's officers, described their quarry as

> a kind of sloth about the size of a roasting pig with a proboscis 2 or 3 inches in length. . . . On the back were short quills like those of the Porcupine. . . . The animal was roasted and found of a delicate flavor.

Bligh himself made a drawing of his creature before the banquet. The officers of the *Providence* had eaten an echidna, one of Australia's most unusual mammals—an egg-laying anteater closely related to the duck-billed platypus.

Bligh brought his drawing back to England. In 1802, it appeared as a plate (reproduced here) accompanying the first technical description of the echidna's anatomy by Everard Home in the *Phil sophical Transactions of the Royal So ety* (G. Shaw had published a prelimina and superficial description in 1792).

Home discovered the strange mix reptilian and mammalian features th has inspired interest and puzzleme among biologists ever since. He also i posed upon the echidna, for the first tim the distinctive burden of primitivity th has continually hampered proper zoolo cal understanding of all monotremes, t egg-laying mammals of Australia. Hon

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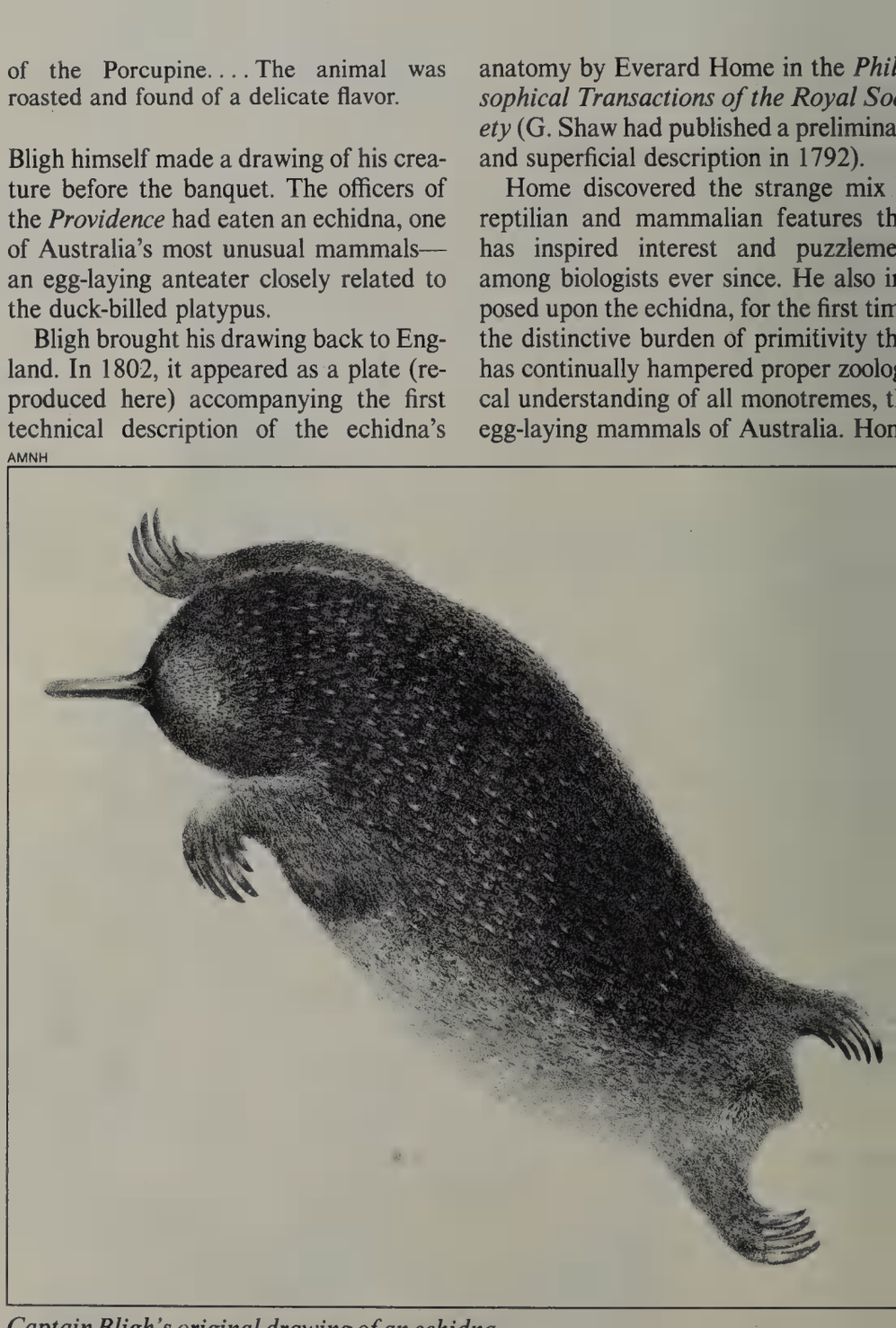

Captain Bligh's original drawing of an echidna

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described the echidna as not quite all there in mammalian terms, a lesser form stamped with features of lower groups:

> These characters distinguish [the echidna] in a very remarkable manner, from all other quadrupeds, giving this new tribe a resemblance in some respects to birds, in others to the Amphibia; so that it may be considered as an intermediate link between the classes of Mammalia, Aves, and Amphibia.

Unfortunately, Home could not study the organ that most clearly belies the myth of primitivity. "The brain," he wrote, "was not in a state to admit of particular examination." Home did have an opportunity to infer the echidna's anomalously large brain from the internal form of its skull, well drawn on the plate just preceding Bligh's figure (and also reproduced here). But Home said nothing about this potential challenge to his general interpretation.

And so the burden of primitivity stuck tenaciously to echidnas, and continues to hold fast in our supposedly more sophisticated age. Some great zoologists have struggled against this convenient fallacy, most notably the early French evolutionist Etienne Geoffroy Saint-Hilaire, who coined the name *Monotremata* (see last month's column) and labored unsuccessfully to establish the echidna and platypus as a new class of vertebrates, separate from both mammals and reptiles and not merely inferior to placentals. By his own manifesto, he chose his strategy explicitly to avoid the conceptual lock that assumptions of primitivity would clamp upon our understanding of monotremes. He wrote in 1827:

> What is defective, I repeat, is our manner of perception, our way of conceiving the organization of monotremes; that is, our determination, made a priori, to join them violently to mammals [by *violemment,* Geoffroy means, of course, "without any conceptual justification"], to place them in the same class and, after our disappointments and false judgments, then to make our unjust grievances heard, as when we speak of them as mammals essentially and necessarily outside the rules.

But Geoffroy's legitimate complaint, so eloquently expressed, did not prevail, and the myth of primitivity continues, despite its blatant flaw. As I argued in last month's column on platypuses, the myth of primitivity rests upon a logical confusion between early branching from the ancestors of placental mammals (the true meaning of reptilian characters retained by monotremes) and structural inferiority. Unless geological age of branching is a sure guide to level of anatomical organization—as it is not—egg laying and interclavicle bones do not brand platypuses and echidnas as inferior mammals.

Beyond this general defense, echidnas can provide ample specific evidence of their adequacy. They are, first of all, a clear success in ecological terms. Echidnas live all over the Australian continent (and extend into Papua-New Guinea), the only native mammal with such a wide range. Moreover, *the* echidna, as a single struggling relict, ranks with *the* rat and *the* monkey (those meaningless synecdoches of the psychological literature) as an absurd abstraction of nature's richness. Echidnas come as two species in two separate genera and with quite different habits. *Tachyglossus aculeatus* (the Australian form with Papuan extensions) rips apart ant and termite nests with its stout forelimbs and collects the inhabitants on its sticky tongue. The larger and longer-snouted *Zaglossus bruijni* of Papua-New Guinea lives on a nearly exclusive diet of earthworms. Moreover, three other species, including the "giant" echidna, *Zaglossus hacketti,* have been found as fossils in Australia. Echidnas are a successful and at least modestly varied group.

But echidnas hold a far more important ace in the hole as their ultimate defense against charges of primitivity. The same cultural biases that lead us to classify creatures as primitive or advanced have established the form and function of brains as our primary criterion of ranking. Echidnas have big and richly convoluted brains. Scientists have recognized this anomaly in the tale of primitivity for more than a century—and they have developed an array of arguments, indeed a set of traditions, for working around such an evident and disconcerting fact. Large brains undoubtedly serve echidnas well; but they also help to instruct us about an important issue in the practice of science—how do scientists treat factual anomalies? What do we do with evidence that challenges a comfortable view of nature's order?

The echidna's brain refutes the myth of primitivity with a double whammy—size and conformation. (I discuss only the Au tralian species, *Tachyglossus aculeatu* its larger Papua-New Guinea relative, *Z glossus,* remains virtually unknown to sc ence—for basic information about echi nas, see the two books by M. Griffith *Echidnas,* Pergamon Press, 1968; ar *The Biology of Monotremes,* Academ Press, 1978.) Since mammalian brains i crease more slowly than body weig along the so-called mouse-to-elepha curve, we can use neither absolute nor re ative brain weight as a criterion. (B mammals have absolutely large brains an uninteresting consequence of body siz while small mammals have relative large brains because brains increase mo slowly than bodies.) Biologists have ther fore developed a standard criterion: me sured brain weight relative to expecte brain weight for an average mammal *the same* body size. This ratio, dubbed E (or encephalization quotient) in amusi analogy with you know what, measur 1.0 for mammals right on the mouse-to-e ephant curve, above 1.0 for brainier tha average mammals, and less than 1.0 f brain weights below the norm.

To provide some feel for the range EQ's, so-called basal insectivores—a s lected stem group among the order trac tionally ranked lowest among placent mammals—record a mean of 0.311. Ad ing advanced insectivores, the avera rises to 0.443. Rodents, a perfectly r spectable group (and dominant amo mammals by sheer number), display mean EQ of 0.652. (Primates and carn vores rank consistently above 1.0.) Mon tremes are not, by this criterion, mental g ants—their EQ's range from 0.50 0.75—but they rank way above the trac tional primitives among placentals ar right up there with rodents and other "r spected" groups. Monotremes continue shine by other standards of size as we Some neurologists regard the ratio brain to spinal cord as a promising me sure of mental advance. Fish generally d below 1:1 (spinal cord heavier than brain We top-heavy humans tip the scale

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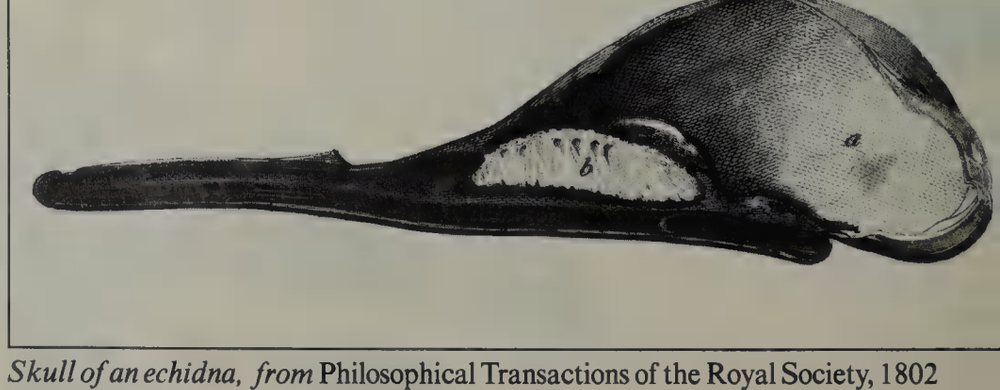

Skull of an echidna, from Philosophical Transactions of the Royal Society, 1802

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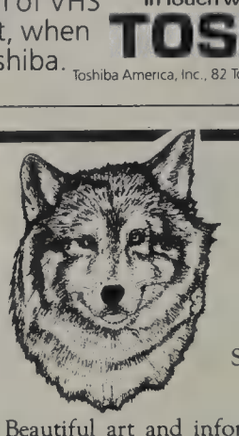

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50:1; cats score 4:1. The "lowly" echidn waddles in front of tabby at approx mately 6:1.

By conformation, rather than simpl size alone, echidnas are even more impres sive. The neocortex, the putative site o higher mental functions, occupies a large percentage of total brain weight in suppos edly advanced creatures. The neocortex o basal insectivores averages 13 percent o brain weight; the North American marsu pial opossum records 22 percent. Echi nas score 43 percent (platypuses 48 pe cent), right up there with the prosimian (54 percent), basal group of the lordly pr mates. (All my figures for brain size come from H.J. Jerison's *Evolution of th Brain and Intelligence,* Academic Pres 1973, and P. Pirlot and J. Nelson, "Volu metric Analysis of Monotreme Brains, *Australian Zoologist,* vol. 20, 1978.)

The neocortex of echidnas is not onl expanded and nearly spherical as in pr mates; its surface is richly convoluted in series of deep folds and bumps (sulci an gyri), a traditional criterion of mental ad vance in mammals. (Curiously, by con parison, the platypus neocortex, whi equally expanded and spherical, is almo completely smooth.)

Many famous nineteenth-century neu roanatomists studied monotreme brain hoping to understand the basis of huma mental triumph by examining its lowly o igins. Echidnas provided an endless sourc of puzzlement and frustration. Willia Henry Flower dissected an echidna 1865 and wrote of "this most remarkab brain, with its largely developed an richly convoluted hemispheres." He ad mitted: "It is difficult to see in many of th peculiarities of their brain even an ap proach in the direction of that of the bird And Grafton Elliot Smith, the great Au tralian anatomist who later fell for Pil down in such a big way, wrote with evide befuddlement in 1902:

The most obtrusive feature of this brain the relatively enormous development of th cerebral hemispheres . . . . In addition, th extent of the cortex is very considerably i creased by numerous deep sulci. The mea ing of this large neopallium is quite incon prehensible. The factors which the study other mammalian brains has shown to the determinants of the extent of the cort fail completely to explain how it is that small animal of the lowliest status in th mammalian series comes to possess th large cortical apparatus.

One might have anticipated that scie tists, so enlightened by monotreme me tality, would simply abandon the myth primitivity. But prompt submission items of contrary evidence is not, despi

other prominent myth (this time about entific procedure), the usual response scientists to nature's assaults upon tra- tional beliefs. Instead, most students of onotreme brains have recorded their rprise and then sought different criteria, ain to affirm the myth of primitivity.

A favorite argument cites the absence monotremes (and marsupials as well) of corpus callosum—the bundle of fibers nnecting the right and left hemispheres "higher" mental processing in placental ammals. In a wonderful example of bla- ntly circular logic, A.A. Abbie, one of ustralia's finest natural historians, wrote a famous article of 1941 (commissures, a neuroanatomist, are connecting bands neural tissue, like the corpus callosum):

nce in mammals cerebral evolution and th it any progressive total evolution is re- cted so closely in the state of the cerebral mmissures it is clear that the taxonomic gnificance of these commissures far tran- ends that of any other physical character.

In other words, since we know (a priori) at monotremes are primitive, search for e character that affirms a lowly status ck of a corpus callosum) and proclaim is character, ipso facto, more important an any other (size of brain, convolutions, any other indication of monotreme ade- acy). (I shall have more to say about mmissures later on, but let me just men- on for now that lack of a corpus callosum es not preclude communication across e cerebral hemispheres. Monotremes ssess at least two other commissures— e hippocampal and the anterior—capa- e of making connections, though by a ute more circuitous than the pathway of e corpus callosum.)

This tradition of switching to another iterion continues in modern studies. In eir 1978 article on monotreme brain zes, for example, Pirlot and Nelson ad- it, after recording volumes and convolu- ons for echidnas: "It is very difficult to olate criteria that clearly establish the rimitiveness' of monotreme brains." But ey seek and putatively find, though they onorably temper their good cheer with t another admission of the puzzling size the monotreme neocortex:

his cortex could be considered to be hong the most primitive mammalian cor- es on the basis of the low number and low nsity of large, especially pyramidal neu- ns. It is surprising to find that a very high oportion of cortex is neocortex. This does t necessarily mean an advanced degree of ogressiveness, although the two are usu- y related.

The basic data on size and external con- rmation of echidna brains have been re-

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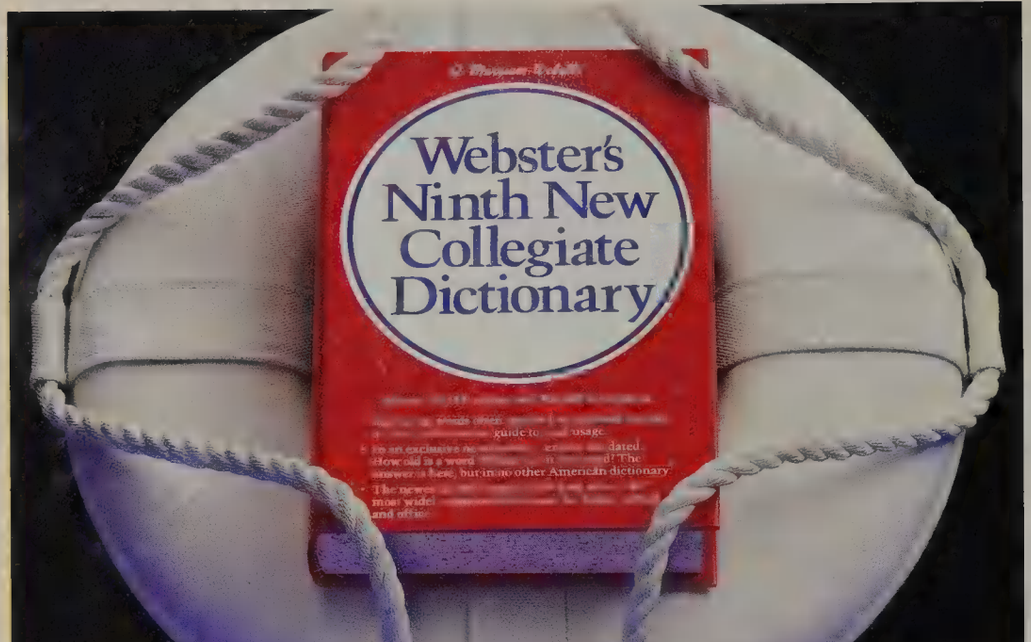

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corded (and viewed as troubling) for mo than a century. More sophisticated formation on neural fine structure and a tual use of the cortical apparatus in lear ing has been gathered during the pa twenty years—all affirming, again ar again, the respectability of echidna intel gence.

In 1964, R.A. Lende (*Journal of Ne rophysiology,* vol. 27) published the fi extensive map of localized sensory ar motor areas on the echidna's cerebral co tex. (I discussed the general procedures such study in August's column on plat pus brains. P. S. Ulinski has recently co firmed and greatly extended Lende's wo in a series of elegant experiments—*Jou nal of Comparative Neurology,* vol. 22 1984.) Lende discovered a surprising pa tern of localization, basically mammali in character but different from placent mappings. He identified separate are for visual, auditory, and sensory contr (the motor area overlapped the sensory r gion and extended forward to an adc tional section of the cortex), all dema cated one from the other by constant sul (fissures of the cortex) and located t gether at the rear of the cortex.

Most surprisingly, these areas abut or another without any so-called associati cortex in between. (Association cortex i cludes areas of the cerebral surface th do not control any specific sensory or m tor function and may play a role in coord nating and integrating the basic input For this reason, amount and position association cortex have sometimes bee advanced as criteria of "higher" ment function. But such negative definitions a troubling and should not be pushed t hard or far.) In any case, Lende identifie a relatively enormous area of unspecifie (perhaps association) cortex in front of h mapped sensory and motor areas. Lend concluded, in a statement oft-quote against those who maintain the myth primitivity:

Ahead of the posteriorly situated senso and motor areas established in this stu there is relatively more "frontal cortex than in any other mammal, including ma the function of which remains unexplaine

Other studies have tried to push th echidna brain to its practical limits by im posing upon these anteaters all the mo ern apparatus of mazes, levers, and foo rewards so favored by the science of com parative psychology. Echidnas have pe formed remarkably well in all these stu ies, again confuting the persistent im pression of stupidity still conveyed b textbooks and even by the most "officia of all sources—the Australian Museum

ɔmplete Book of Australian Mammals, ited by R. Strahan (Sydney: Angus and ɔbertson, 1983), which insists without idence:

this last respect [brainpower], mono-emes are inferior to typical placental ammals and, probably, to typical marsu-als. The paucity of living monotremes ay therefore be due to their being less ight, less adaptable in their behavior, an other mammals.

To cite just three studies among several similar intent and conclusion:

1. Saunders, Chen, and Pridmore (in *nimal Behavior,* 1971) ran echidnas rough a simple two-choice T-maze own a central channel, then either right left into a bin of food or a blank wall). ney trained echidnas to move in one di-ction (location of the chow, of course), en switched the food box to the other m of the T. In such studies of so-called bit-reversal learning, most fish never vitch, birds learn very slowly, mammals pidly. Echidnas showed quick improve-ent with a steady reduction in errors—d at typically mammalian rates. Half e experiments (seven of fifteen) on well-ained echidnas yielded the optimal per-rmance of "one-trial reversal" (you vitch the food box and the animal goes e wrong way—where the food used to —the first time, then immediately cot-ns on and heads in the other direction, ward the chow, each time). Rats often ow one-trial reversal learning, birds ver.

2. Buchmann and Rhodes (*Australian oologist,* 1978) tested echidnas for their bility to learn positional (right or left) d visual-tactile (black and rough versus hite and smooth) cues—with echidnas shing the appropriate lever to gain their od reward. As an obvious testimony to ental adequacy, they report that "unsuc-ssful (unrewarded) responses were often sociated with vigorous kicking at the beranda." Echidnas learned at a charac-ristic rate for placental mammals and so remembered well. One animal, re-sted a month later, performed immedi-e one-trial reversals.

Buchmann and Rhodes compared their chidnas with other animals tested in simi-r procedures. Crabs and goldfish did not ow improvement (did not learn) over me. Echidnas displayed great variation their speed of learning—one improved ster (and one slower) than rats and men-lly retarded humans: all echidnas per-rmed better than cats. Take these re-lts (not to mention the reward for ccess) with a grain of salt because num-ers are limited and procedures varied idely among studies—but still, the single

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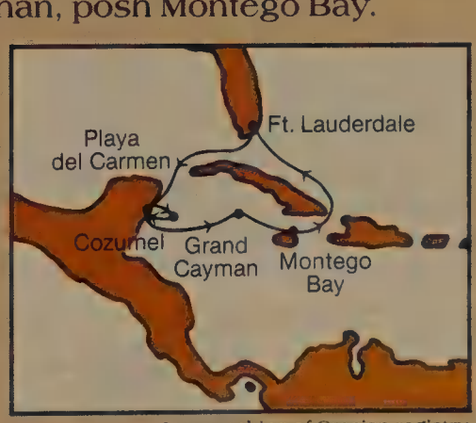

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best performer on the entire chart was an echidna.

Buchmann and Rhodes conclude: "There is no evidence that the performance of echidnas is inferior to eutherian [placental] or metatherian [marsupial] mammals." They end by ridiculing the "quaint, explicitly or tacitly-held views that echidnas are little more than animated pin-cushions, or, at the best, glorified reptiles."

3. Gates (*Australian Zoologist,* 1978) studied learning in visual discrimination (black versus white, and various complex patterns of vertical and horizontal striping). His results parallel the other studies—echidnas learned quickly, at typical mammalian rates. But he added an interesting twist that confutes the only serious, direct argument ever offered from brain anatomy for monotreme inferiority—the claim that lack of a corpus callosum precludes transfer between the cerebral hemispheres, thereby compromising "higher" mental functions.

Gates occluded one eye and taught echidnas to distinguish black from white panels with the other eye. They reached "criterion performance" in an average of 100 trials. He then uncovered the occluded eye, bandaged the one that had overseen the initial learning, and did the experiment again. If no information passed from one cerebral hemisphere to the other, previous learning on one side of the brain should offer no help to the other, and the 100-trial average should persist. But echidnas only needed 40 trials to reach criterion with the second eye.

Gates conjectures that information is either passing across one of the other two commissures in the absence of a corpus callosum, or via the few optic fibers that do not cross to the other side of the brain. (In vertebrate visual systems, inputs from the right eye go to the left hemisphere of the brain, left eye to the right hemisphere; thus, each eye "informs" the opposite hemisphere. But about 1 percent of optic fibers do not cross over, and therefore map to their own hemisphere. These few fibers may sneak a little learning to the hemisphere dependent upon the occluded eye.) In addition, direct evidence of electrical stimulation has shown that inputs to one hemisphere can elicit responses in corresponding parts of the other hemisphere—information clearly gets across in the absence of a corpus callosum.

The solution to the paradox of such adequate intelligence in such a primitive mammal is stunningly simple. The premise—the myth of primitivity itself—is dead wrong. To say it one more, and one last, time: the reptilian features of monotremes only record their early branchin from the ancestry of placental mar mals—and time of branching is no me sure of anatomical complexity or ment status.

Monotremes have evolved separate from placentals for a long time—mo than enough for both groups to reach, b parallel evolution in independent lineage advanced levels of mental functioning pe mitted by their basic, shared mammalia design. The primary evidence for parall evolution has been staring us in the fa for a century; it forms part of the standa literature on echidnas, well featured ev in primary documents that uphold th myth of primitivity. We know that th echidna's brain attained its large size b an independent route. The platypus has smooth (if bulbous) brain. The echidn evolved the complex ridges and folds of cerebral surface as a special feature of own lineage. These sulci and gyri cann be identified (homologized) with the we known convolutions of placental brain The echidna brain is so different, by virt of a separate evolution to large size, th its convolutions have been named Greek letters to avoid any misplaced co parison with the different ridges and fol of placental brains. And Grafton Elli Smith, the man most puzzled by echid brains, did the naming—apparently wit out realizing that the very need for su separate designations embodied the dire evidence that could refute the myth primitivity.

In his eloquent plea for monotrem (1827), Geoffroy Saint-Hilaire wrote br liantly about the subtle interplay of fa and theory in science. He recognized t power of theory to guide the discovery fact and to set a context for fruitful int pretation. ("To limit our efforts to the si ple practicalities of an ocular examinati would be to condemn the activities of t mind.") But he also acknowledged the f side of useful guidance, the extraordina power of theory to restrict our vision, particular to render "obvious" facts nea invisible, by denying them a sensible co text. ("At first useless, these facts had remain unperceived until the mome when the needs and progress of scien provoked us to discover them.") Or Warner Oland, the Swedish pseudo-C ental Charlie Chan, once said in one of most delightfully anachronistic pseu Confucian sayings (*Charlie Chan Egypt,* 1935): "Theory like mist on e glasses. Obscure facts."

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Disease and Death at Dr. Dickson's Mounds

The skeletal remains of prehistoric Native Americans show that agricultural revolutions can be hazardous to your health

by Alan H. Goodman and George J. Armelagos

Clustered in west-central Illinois, atop a bluff near the confluence of the Illinois and Spoon rivers, are twelve to thirteen poorly defined earthen mounds. The mounds, which overlap each other to some extent, cover a crescent-shaped area of about an acre. Since at least the middle of the nineteenth century, local residents have known that prehistoric Native Americans built these mounds to bury their dead. But it was not until the late 1920s that Don Dickson, a chiropractor, undertook the first systematic excavation of the mounds, located on farmland owned by his father. Barely into his thirties at the time, Dickson became so involved in the venture that he never returned to his chiropractic practice. Apparently, he was intrigued by the novel undertaking of unearthing skeletons and trying to diagnose the maladies of long-dead individuals. Later on, he became more concerned with the patterns of disease and death in this extinct group in order to understand how these people lived and why they often died at an early age.

The "Dickson Mounds" (the site also includes two early, unmounded burial grounds) quickly attracted the attention of professional anthropologists. In the early 1930s, a team of University of Chicago archeologists exposed about 200 of the estimated 3,000 burials and identified a number of settlement sites in a 100-square-mile area. A second phase of excavation at Dickson began in the 1960s under the direction of Alan Harn, an archeologist working for the state of Illinois, whose crew excavated many of the local living sites and more than 800 additional burials. The archeological research revealed that these prehistoric people had taken part in an important transition, from hunting and gathering to an agricultural way of life.

About A.D. 950, hunter-gatherers lived along the Illinois River valley area near Dickson, subsisting on a wide range of local plants and animals, including grasses and seeds, fruits and berries, roots and tubers, vines, herbs, large and small mammals, migratory waterfowl and riverine birds, and fish. The moderate climate, copious water supply, and rich soil made this a bountiful and attractive area for hunter-gatherers. Groups occupied campsites that consisted of a few small structures, and the debris scattered around these sites suggests seasonal use. The population density was low, perhaps on the order of two to three persons per square mile. Then, about 1050, broken hoes and other agricultural tools, as well as maize, began to form part of village refuse, evidence of the introduction of maize agriculture. At the same time, the population grew. By 1200 the population density may have increased by a factor of ten, to about twenty-five persons per square mile. Living sites became larger and more permanent. The largest settlement in the area, Larson, was a residential and ceremonial center where some 1,000 inhabitants lived, many behind a palisaded wall.

Trade also flourished. Dickson became part of what archeologists call the Mississippian tradition, a network of maize-growing, mound-building societies that spread throughout most of the eastern United States. More and more, items used at the village sites or deposited as grave offerings were not of local origin. Some, such as marine shell necklaces, came from as far away as the Gulf of Mexico and Florida, one thousand miles to the south. Everyday objects such as spoons and jars were received from peoples of the eastern plains and the western prairies, while luxury items of ceremonial or decorative value arrived in trade from the south, probably coming upriver to Dickson through Cahokia, a Mississippian center some 110 miles away. Cahokia is a massive site that includes some 120 mounds within a six-square-mile area. As many as 30,000 persons lived at Cahokia and in the surrounding villages.

What we know about Dickson might have ended at this point, but continues because the skeletal remains that Harn excavated have been used to evaluate how the

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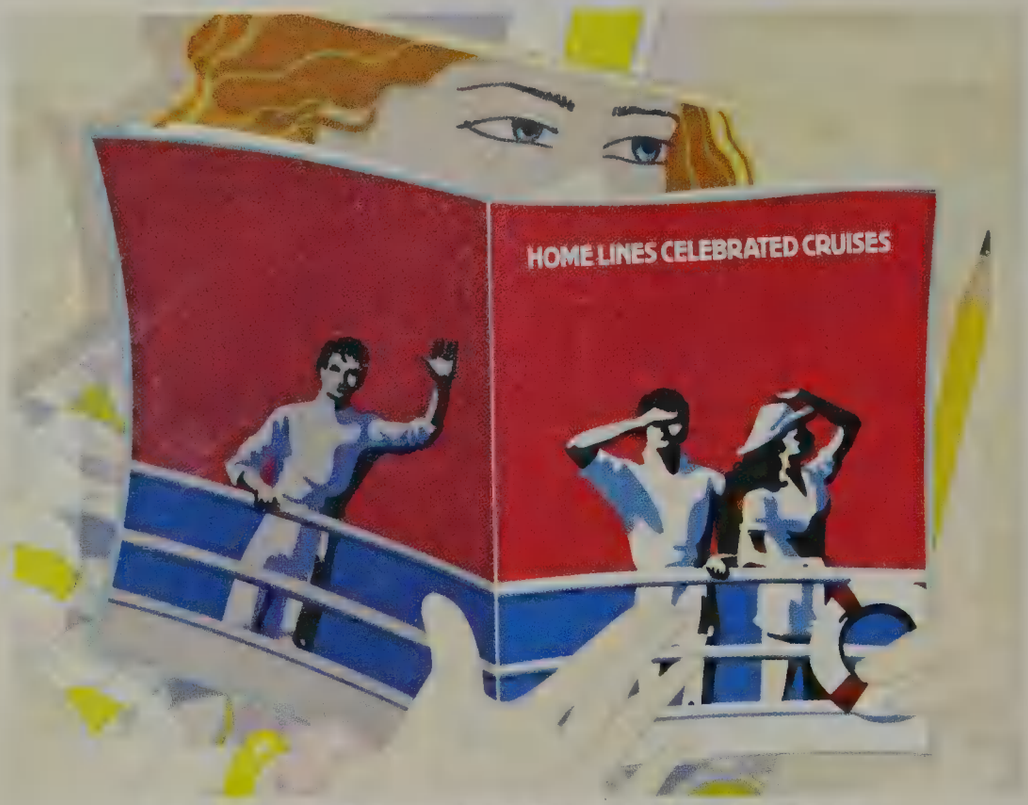

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health of these prehistoric people fared following the adoption of agriculture and other changes in their life style. Interest in this issue stems from the writings of the eminent British archeologist V. Gordon Childe (1892–1957), who believed that the development of agriculture prompted the first great revolution in human technology, ushering in fundamental changes in economy, social organization, and ideology. Archeologists continue to debate the causes of agricultural revolutions. For example, some believe that in various regions of the world, increased population pressure, leading to food shortages and declining health, spurred the switch to agricultural food production. Others believe population increase was one of the consequences of agricultural revolutions. More important to us are the effects of an agricultural revolution on the health of people who lived at the time of such change.

Three circumstances have made it possible to test the effects agriculture had upon health at Dickson. First, Harn and those working with him valued the potential information to be gained from skeletons and therefore paid close attention to their excavation. Ultimately, the skeletal remains were sent to the University of Massachusetts at Amherst for analysis by George Armelagos and many of his graduate students (this is how we became involved). Second, the recovered remains include both individuals who lived before the development of maize agriculture (Late Woodland, or pre-Mississippian) and after (Mississippian). The two groups of individuals could be distinguished according to the mounds they were buried in, their placement within each mound and their burial position (in earlier burials the bodies tend to be in a flexed or semiflexed position; in later burials they tend to be extended). The third enabling condition was provided by Janice Cohen, one of Armelagos's graduate students. Her analysis of highly heritable dental traits showed that although Dickson was in contact with persons from outside the central Illinois River valley area during the period of rapid cultural change, outside groups did not replace or significantly merge with the local groups. It is therefore possible to follow the health over time of a single population that, for all intents and purposes, was genetically stable.

As a doctoral student working under Armelagos in the early 1970s, John Lallo, now at Cleveland State University, set out to test whether health at Dickson improved, got worse, or remained the same with the advent of agriculture and its accompanying changes. Lallo argued that intensification of maize agriculture most

likely resulted in a poorer diet. Although a common assumption is that the adoption of agriculture should have provided a prehistoric people with a better diet, there are good reasons to predict just the opposite. Heavy reliance on a single crop may lead to nutritional problems. Maize, for example, is deficient in lysine, an essential amino acid. Furthermore, agricultural societies that subsist on a few foodstuffs are more vulnerable to famines brought about by drought and other disasters. Finally, increased population density, a more sedentary life style, and greater trade, all of which are associated with agriculture, provide conditions for the spread and maintenance of infectious diseases.

The skeletons of individuals who lived before and after the introduction of maize agriculture were examined for a number of different health indicators, in order to provide a balanced picture of the pattern of stress, disease, and death that affected the Dickson population. The indicators that proved most sensitive to health differences were: bone lesions (scars) due to infection, nutritional deficiencies, trauma, and degenerative conditions; long bone growth; dental developmental defects; and age at death. To avoid unconscious bias, we and the other researchers involved measured these seven traits without knowing in advance which skeletons came from each of the two cultural periods.

Persistent bacterial infection leaves its mark on the outer, or periosteal, layer of bone. Tibias (shinbones) are the most frequently affected bones because they have relatively poor circulation and therefore tend to accumulate bacteria. Toxins produced by bacteria kill some of the bone cells; as new bone is produced, the periosteal bone becomes roughened and layered. Lallo and his co-workers found that following the introduction of agriculture there was a threefold increase in the percentage of individuals with such lesions. Eighty-four percent of the Mississippian tibias had these "periosteal reactions," as compared with only 26 percent of pre-Mississippian tibias. The lesions also tended to be more severe and to show up in younger individuals in the Mississippian population.

A second type of lesion, more easily seen in the thinner bones of the body (such as those of the skull), is a sign of anemia. In response to anemia, the body steps up its production of red blood cells, which are formed in the bone marrow. To accomplish this the marrow must expand at the expense of the outer layer of bone. In severe cases, this expansion may cause the outer layer of bone to disappear, exposing the porous, sievelike inner bone. This le-

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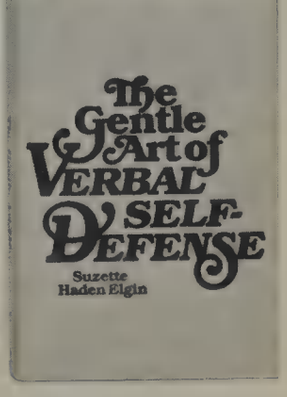

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sion, called porotic hyperostosis, can occur with any kind of anemia. In the Dickson Mounds populations, the lesions are not severe, are restricted to the eye sockets and crania, and occur mainly in children and young adult females. This pattern suggests anemia resulting from a nutritional deficiency, specifically an iron deficiency. (A hereditary anemia, such as sickle-cell anemia, would have been more severe in its manifestation and would have affected all ages and both sexes in the population.)

There is a significant increase in the frequency of porotic hyperostosis during the Mississippian period. Half the Mississippian infants and children had porotic hyperostosis, twice the rate found for pre-Mississippian infants and children. Individuals with both periosteal reactions and porotic hyperostosis tend to have suffered more severely from each condition. This may be evidence of a deadly synergism of malnutrition and infection, like that often reported among contemporary populations.

Traumatic lesions were measured by diagnosis of healed fractures of the long bones of the legs and arms. Adult males had the highest frequency of such fractures. Approximately one out of three Mississippian males had at least one fracture, twice the frequency of their predecessors. These fractures often occurred at the midshaft of the ulna and radius, the bones of the lower arm. Fractures at this location are called parry fractures because they are typically the result of efforts to ward off a blow.

The frequency of degenerative pathologies, including arthritic conditions found on joints and the contacting surfaces of the vertebral column, also increased through time. One or more degenerative conditions were diagnosed in 40 percent of pre-Mississippian adults but in more than 70 percent of Mississippian adults.

In addition to the studies of the changing pattern of disease and trauma, we, along with Lallo and Jerome Rose, now at the University of Arkansas, assessed differences in skeletal growth and developmental timing. Skeletal growth and development are susceptible to a wide variety of stressful conditions and therefore reflect overall health. We found that in comparison to pre-Mississippians of the same age, Mississippian children between the ages of five and ten had significantly shorter and narrower tibias and femurs (the major long bones of the legs). This difference may be explained by a decreased rate of growth before the age of five. The Mississippians apparently were able to catch up in growth after age ten, however, since adult Mississippians are only slightly smaller than pre-Mississippians.

A more detailed exploration of developmental changes came from studying defects in enamel, the hard white coating of the crowns of teeth. Ameloblasts, the enamel-forming cells, secrete enamel matrix in ringlike fashion, starting at the biting surface and ending at the bottom of the crown. A deficiency in enamel thickness, called a hypoplasia, may result if the individual suffers a systemic physiological stress during enamel formation. Since the timing of enamel secretion is well known and relatively stable, the position of such a lesion on a tooth corresponds to an individual's age at the time of stress.

We examined the permanent teeth—teeth that form between birth and age seven. For skeletons with nearly complete sets of permanent teeth, 55 percent of pre-Mississippians had hypoplasias, while among Mississippians the figure rose to 80 percent. In both groups, hypoplasias were most frequently laid down between the ages of one and one-half and four. However, the hypoplasias in the Mississippian group peak at age two and one-half, approximately one-half year earlier than the pre-Mississippian peak. The peak is also more pronounced. This pattern of defects may indicate both an earlier age at weaning and the use of cereal products as weanling foods.

The repeated occurrence of hypoplasias within individuals revealed an annual cy-

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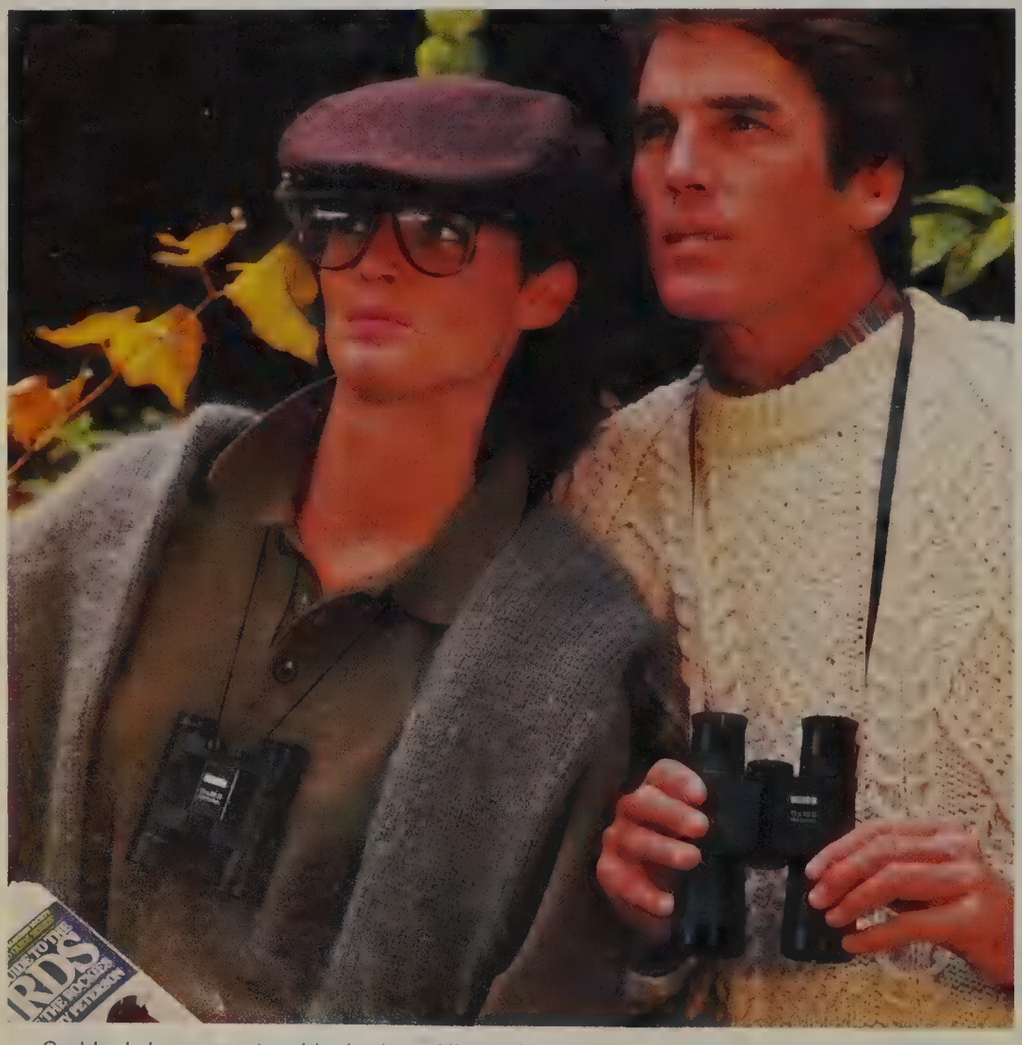

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e of stress. Most likely there was a sea-nal food shortage. This seems to have orsened in the period just before the pulation becomes completely "Missis-ppianized," suggesting that it provided a tionale for intensifying agriculture.

All the above six indicators point to-ard a decrease in health associated with ltural change at Dickson. However, ey are not meaningful apart from an alysis of the pattern of death in these pulations. Healthy-looking skeletons, r example, may be the remains of young dividuals who died outright because eir bodies were too weak to cope in the ce of disease, injury, and other forms of ess. Conversely, skeletons that show ear and tear may be those of individuals no survived during stressful times and ed to a ripe old age.

At Dickson, however, the trend is un-nbiguous. Individuals whose skeletons owed more signs of stress and disease r example, enamel hypoplasias) also ed shorter lives, on average, than indi-duals with fewer such indications. For e population as a whole, life expectancy birth decreased from twenty-six years the pre-Mississippian to nineteen years the Mississippian. The contrast in mor-lity is especially pronounced during the infant and childhood years. For example, 22 percent of Mississippians died during their first year as compared to 13 percent of the pre-Mississippians. Even for those who passed through the dangerous early years of childhood, there is a differential life expectancy. At fifteen years of age, pre-Mississippians could expect to live for an average of twenty-three more years, while Mississippians could expect to live for only eighteen more years.

What caused this decline in health? A number of possibilities have been proposed. Lallo and others have emphasized the effect of agriculture on diet. Most of the health trends may be explained by a decline in diet quality. These include the trends in growth, development, mortality, and nutritional disease, all four of which have obvious links to nutrition. The same explanation may be offered for the increase in infectious diseases, since increased susceptibility may be due to poor nutrition. Furthermore, a population subject to considerable infectious disease would be likely to suffer from other conditions, including increased rates of anemia and mortality and decreased growth rates.

The link between diet and infectious disease is bolstered by an analysis of trace elements from tibial bone cores. Robert Gilbert found that the Mississippian bones contain less zinc, an element that is limited in maize. Building on this research, Wadia Bahou, now a physician in Ann Arbor, Michigan, showed that the skeletons with the lowest levels of zinc had the highest frequency of infectious lesions. This is strong evidence that a diet of maize was relied on to a point where health was affected.

The population increase associated with the changeover to agriculture probably also contributed to the decline in health. We do not believe that the population ever threatened to exceed the carrying capacity of the bountiful Dickson area (and there are no signs of the environmental degradation one would expect to find if resources were overexploited). However, increased population density and sedentariness, coupled with intensification of contact with outsiders, create opportunities for the spread of infectious disease. George Milner of the University of Kentucky, while still a graduate student at Northwestern University, argued this point in comparing Dickson with the Kane Mounds populations. Kane is located near Cahokia, the major center south of Dickson. Despite Kane's proximity to this large center, its population density was

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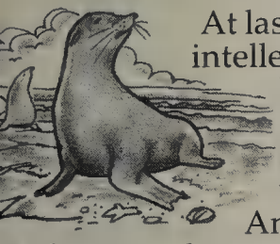

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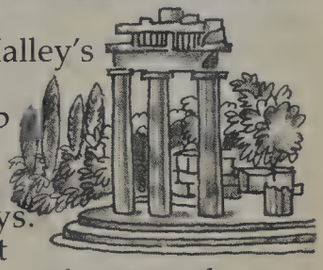

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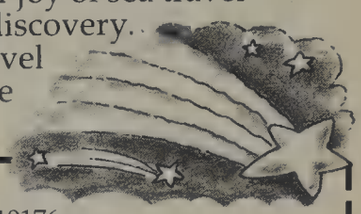

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much lower than at Larson, the major agricultural village of the Dickson population. Of the two, Kane had the lower rate of infectious diseases.

While the "agricultural hypothesis," including the effects of population pressure, offers an explanation for much of the health data, it doesn't automatically account for the two remaining measures: degenerative and traumatic pathologies. Poor nutrition and infectious disease may make people more susceptible to degenerative disease. However, the arthritic conditions found in the Dickson skeletons, involving movable joints, were probably caused by strenuous physical activity. The link, then, is not with the consumption of an agricultural diet but, if anything, with the physically taxing work of agricultural production. An explanation for the increase in traumatic injuries is harder to imagine. Possibly, the increased population density caused social tension and strife to arise within communities, but why should this have happened?

A curious fact makes us think that explanations based only on agricultural intensification and population increase are missing an important contributing factor. Recent archeological research at Dickson suggests that hunting and gathering remained productive enterprises and were never completely abandoned. Many of the local Mississippian sites have a great concentration of animal bones and projectile points used for hunting. A balanced diet apparently was available. The health and trace element data, however, suggest that the Mississippian diet was deficient. There is a disparity between what was available and what was eaten.

At present our search for an explanation for this paradox centers on the relationship between Dickson and the Cahokia population. The builders of the Dickson Mounds received many items of symbolic worth from the Cahokia region, such as copper-covered ear spools and marine shell necklaces. Much of the health data would be explained if Dickson had been trading perishable foodstuffs for these luxury items. In particular, the diversion of meat or fish to Cahokia would explain the apparent discrepancy between diet and resources.

To have a food surplus to trade, individuals from the Dickson area may have intensified their agricultural production while continuing to hunt and gather. The increase in degenerative conditions could have resulted from such a heavy workload. The system may also have put social strain on the community, leading to internal strife. And the accumulation of wealth in terms of ceremonial or other luxury items may have necessitated protectio from outside groups. This would explai why the Larson site was palisaded. Bot internal and external strain may have le to the increase in traumatic pathologies

To test the validity of this scenario, w are hoping to gather additional evidenc concentrating on an analysis of trade. Th flow of perishable goods such as meat hard to trace, but we can study the sets c animal bones found at Cahokia and a Dickson village and butchering sites. Th distribution of animal bones at the archeo logical sites can then be compared wit examples of bone distributions in area where trading has been ethnographicall recorded. Further evidence is provided b data such as Milner's, which showed tha health at Kane—a community tha shared in Cahokia's power—was bette than at Dickson.

The trading of needed food for items c symbolic value, to the point where healt is threatened, may not seem to make sens from an objective, outsider's perspectiv But it is a situation that has been observe in historic and modern times. An indige nous group learns that it can trade some thing it has access to (sugar cane, alpaca turtles) for something it greatly admire but can only obtain from outside group (metal products, radios, alcohol). Th group's members do not perceive that th long-term health and economic results c such trade are usually unfavorable. No are all such arrangements a result of vo untary agreement. The pattern of healt observed at Dickson is seen in most situa tions where there is a decline in access to and control over, resources. For example lower classes in stratified societies liv shorter lives and suffer more from nearl all major diseases.

Agriculture is not invariably associate with declining health. A recent volum edited by Mark N. Cohen and George J Armelagos, *Paleopathology and th Origins of Agriculture*, analyzed healt changes in twenty-three regions of th world where agriculture developed. I many of these regions there was a clea concurrent decline in health, while in oth ers there was little or no change or sligh improvements in health. Perhaps a declin is more likely to occur when agriculture i intensified in the hinterland of a politica system. Groups living far away from th centers of trade and power are apt to be a a disadvantage. They may send the bes fruits of their labors to market and receiv little in return. And during times of eco nomic hardship or political turmoil, they may be the ones to suffer the most, as re sources are concentrated on maintainin the central parts of the system. □

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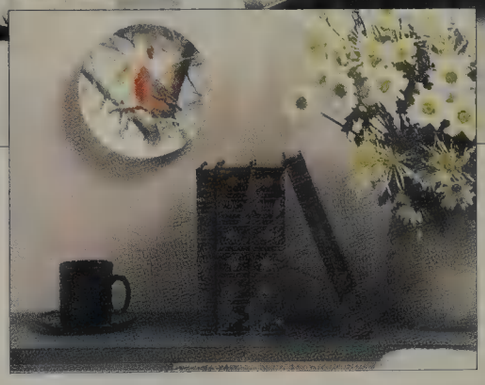

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The Rainmakers

A succession of individuals have devoted their talents to milking the clouds—and the people

by Gerald Carson

When the nomadic societies of primitive hunters and gatherers settled down as agriculturists, they acquired a more abundant food supply, and along with it a paralyzing fear that the rains would not come and the crops would wither. But perhaps nature's droughts could be controlled. The wish led to the belief that such a goal was achievable.

And so sorcerers and great chiefs and priests arose to act as rainmakers. They were wiser than common men or at least cleverer, guardians of secret charms, intercessors presumably capable of conciliating the gods or angry spirits. All were, according to the late social anthropologist Sir James George Frazer, "more or less conscious deceivers," which does not rule out self-deception.

One approach to rainmaking was based upon sympathetic, or imitative, magic; that is, the notion that like produces like, that the effect resembles the cause. So some tribes squirted water on each other or imitated the calls of aquatic birds or, as in Uganda, set out pots of water to draw down the rain when the pasturage failed. Animal sacrifice was believed to be effective provided the animals were black, the color of storm clouds. Later came the idea of a pantheon of gods who controlled the phenomena of nature. Among the Greeks, rain was supposed to come from the supreme deity, Zeus, who poured water through a sieve: Homer speaks in the *Iliad* of "the rain of Zeus." The Romans' sky god was Jupiter. In time of drought the women of Rome, with bare feet and streaming hair, went in procession up the slope to the Capitol, seat of the Jupiter cult, to offer prayers. And a millennium later, the people of Santa Barbara, in southern California, petitioned the mission authorities to allow them to carry the Virgin, Nuestra Señora del Rosario, in procession through the town with prayers and supplications for rain.

Plutarch, writing of a great battle that occurred in 102 B.C., believed that noise produced rain. Since nature's rain was accompanied by thunder, people might get the same results in the same way. This association of ideas eventually came to link weather control with concussion. In the sixteenth century Benvenuto Cellini wrote that he had brought on rain by artillery fire. Church bells have been rung in France and Italy to jar the air and so wring precipitation from the skies, and a modern scholar, Clark C. Spence, a professor of American history at the University of Illinois, has noted that "shooting with cannon, handguns, and rockets, was common in the Beaujolais wine districts almost to the twentieth century."

The concussion theory is probably the most widespread and durable of all popular beliefs connected with compelling the skies to give up their moisture. In the United States there was the opinion that the Fourth of July is usually wet because of the patriotic noise released during an old-fashioned Fourth. In 1880 U.S. patent No. 230,067 was granted to Daniel Ruggles of Virginia, a former Confederate general, who owned a ranch along the Rio Grande in Texas, for a scheme to send up a balloon loaded with explosives. Ruggles encouraged the ideas of another concussionist, Edward Powers, a Chicago civil engineer, who wrote an influential book, *War and the Weather; or, The Artificial Production of Rain* (1871).

Powers listed some two hundred battles that were accompanied by rain. Since most battles were fought in the temperate zone, with rain expected on an average of

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Devices for making rain are set up in Nebraska. Drought makes the Great Plains the natural habitat of the rainmaker.

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about every three days, opponents pointed to coincidence as the explanation. However, Powers, Ruggles, and U.S. senator Charles B. Farwell lobbied successfully to get the federal government into rainfall experiments. In 1891, without the blessing of professional meteorologists, Congress directed the Department of Agriculture to conduct experiments with explosives. The tests were carried out by a Washington patent attorney, Robert St. George Dyrenforth. He exploded both ground charges and balloons filled with a highly combustible mixture.

Results? Well, it depended upon the angle of vision. One day rain fell. Another it didn't. When .02 inches was recorded, the *Washington Post* charitably called it "a hard rain." On another occasion, when the weather bureau had predicted showers, a thunderstorm dropped its load of wetness, but mostly somewhere other than where it was supposed to. The press ignored this geographical discrepancy, and the *New York Sun* sang: "I am cloud-compelling Dyrenforth, a might able wight; I can call the clouds together with a load of dynamite."

But *Puck*, the humorous magazine of the period, expressed its skepticism poetically, too: "And while they watch for drops of water,/It falls just where it hadn't orter/By tons, in every other quarter."

The topic of making rain through concussion may be concluded by reference to a prominent businessman who spent some $50,000 on a hunch. During 1906 and 1907, Charles W. Post, the Battle Creek, Michigan, breakfast food millionaire, acquired 213,324 acres of high plains land in Garza, Lynn, and Hockley counties, Texas, but found that lack of water made it impossible to develop his properties as he had hoped. Post had talked with many Civil War veterans about their wartime experiences and concluded that artillery fire and rain were connected. Rain followed thunder. Cannons made thunder. Why not find out once and for all if a bombardment of the sky could produce rain? "I don't undertake the task of rain-making as a disciple of science," the Battle Creek empiric explained, "but because the crops . . . need rain."

Explosives attached to kites were discharged over the area in a series of spectacular "rain battles," and also at Battle Creek, where, following the aerial warfare, a soaking rain descended. The U.S. Weather Bureau pointed out, however, that it rained that day from the Great Lakes to the Pacific Ocean. Rain doctoring, *Scientific American* commented, was an incurable disease.

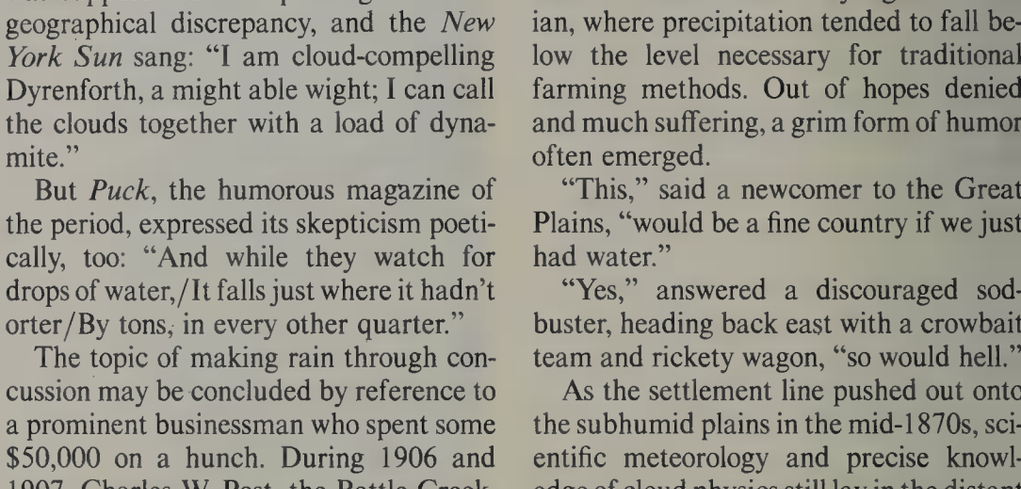
The elemental human need for rain intensified west of the ninety-eighth meridian, where precipitation tended to fall below the level necessary for traditional farming methods. Out of hopes denied and much suffering, a grim form of humor often emerged.

"This," said a newcomer to the Great Plains, "would be a fine country if we just had water."

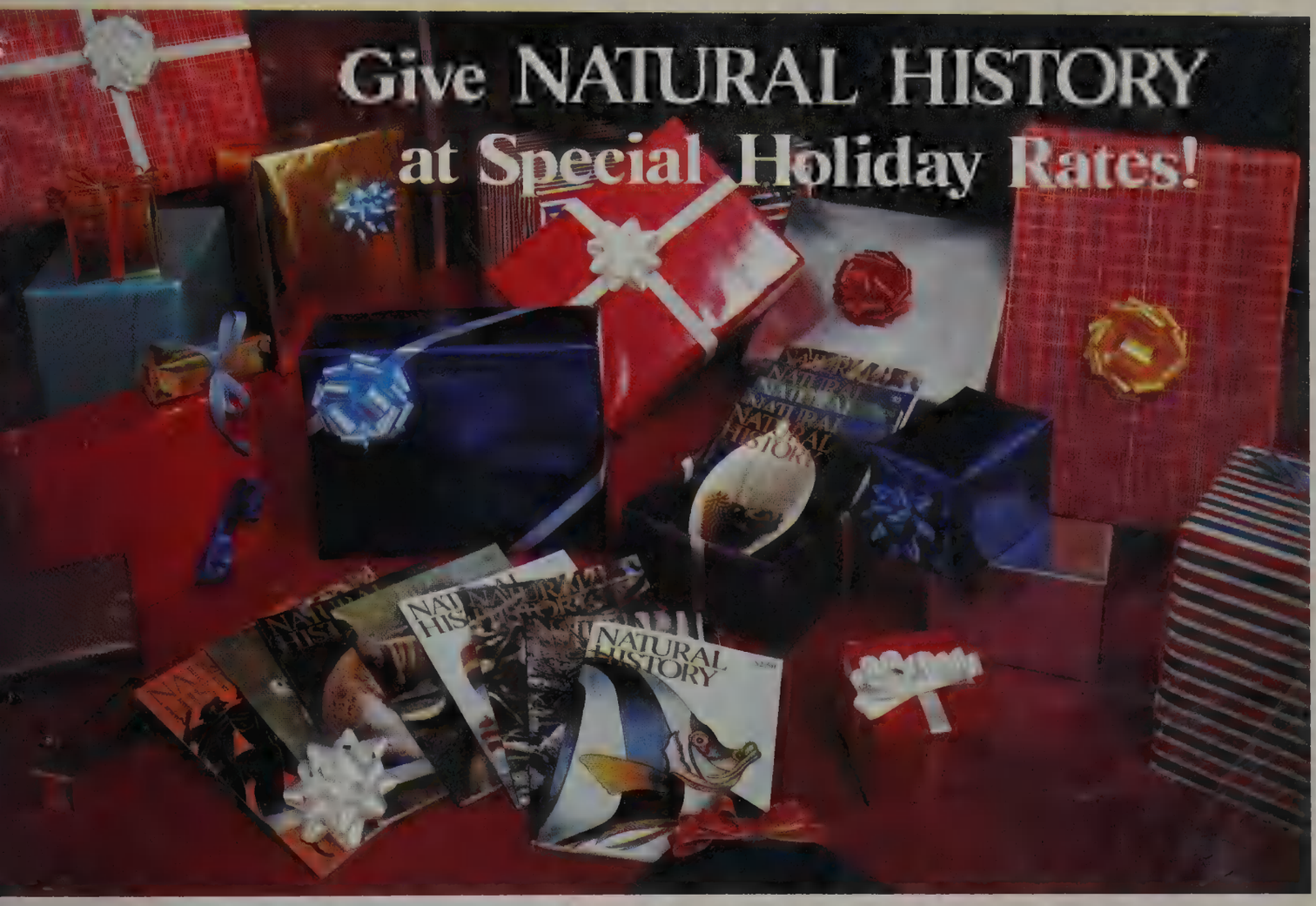
"Yes," answered a discouraged sodbuster, heading back east with a crowbait team and rickety wagon, "so would hell."

As the settlement line pushed out onto the subhumid plains in the mid-1870s, scientific meteorology and precise knowledge of cloud physics still lay in the distant future. There was a general indifference to theoretical science in the United States during much of the nineteenth century; a "get ahead" economic philosophy emphasized the immediately useful. Exceptions

Scientific American



The Dyrenforth Rainmaking Expedition in Texas (1892) exploded ground charges and balloons in an effort to make rain.



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o come to mind, such as Joseph Henry, rst secretary and director of the Smithsoian Institution, an investigator who did asic work in electromagnetics and initited the use of telegraphic reports for veather predictions and storm warnings; nd Joseph Leidy, a naturalist who made ontributions of permanent value in every ranch of zoology. To the list may be dded the name of James P. Espy, a serius student of cloud thermodynamics, vho as early as 1830 described the upvard movement of warm air as the precondition to the formation of clouds, the ooling of the air, and the condensation of s moisture into raindrops. Espy was ever regarded as a fraud, but neither was e a success. He ended up with a modest iche in a government bureau, studying torms without producing any. So folk befs filled the knowledge vacuum. In adition to the concussion theory, other deas that gained acceptance included:

- The notion that plowing up the land nade it rain, a doctrine warmly embraced by the rainbelters—those farmers who ettled on the semiarid plains during a wet ear, relying upon a continuance of the generous rainfall. Abnormally heavy rainfall after the Civil War seemed to confirm he maxim, "Rain follows the plow."

- A theory that railroad and telegraph ines increased rain because of the electricity in the wires or in the current running along the steel rails.

- The idea that planting trees induced ain, which makes it understandable that he first Arbor Day was celebrated in 872 in Nebraska.

- The release of chemical gases to induce ain.

- And prayer. Whether the showers that lways finally came were of divine origin or not, it was incontrovertible, as a saying of the short-grass country had it, that "every dry spell ends with a rain."

Maybe, it was said, the climate was changing—wishful thought based upon he misinterpretation of the natural cycles of weather. Farmers on the hard-soil buffalo-grass plains said, "The country is becoming more seasonable." Hope fathered he thought. And when the corn wilted in he heat—the leaves curled up and the ears were only nubbins—when the pastures turned brown and the rain barrel was ow, then desperate men saw shimmering mirages of freshwater lakes and embraced he expedients of despair. The moment for he entry of the rain wizard had come.

Many of them are now forgotten—rogues, mystics, opportunists, flat-earth believers, self-deluders—but some left a mark. Clayton B. Jewell was a dispatcher for the Chicago, Rock Island, and Pacific Railroad Company who attracted the attention of Rock Island officials because of experiments he had made with rockets and gases. Good crops would bring emigrants, boost land values, generate freight traffic. So the Rock Island fitted out a special laboratory car, eventually expanded to three cars, for the rainmaker and his associates. They toured Kansas and made sorties into Oklahoma, Texas, Nebraska, and South Dakota. As with all the rain compellers, Jewell's formulas and methods were secret, but curious observers did

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A handbill advertises the appearance of Frank Melbourne, the Rain Wizard, at a local fair.

report glimpses of bottles, pipes, tanks, electric wires, and a pipe in the car's roof from which chemicals escaped. Jewell claimed he had brought down rain sixty-six times. On one occasion, according to a Kansas newspaper, so much precipitation followed the magician's ministrations that a farmer implored Jewell to put a stop to the deluge or his calves would drown. Jewell replied rather jauntily: "Machine's wound up for ninety days. Same price for stopping as for starting. Teach the calves to swim." Other railroads showed some interest but the Rock Island dropped the experiments. Jewell moved on to California, where he failed to milk the clouds near Los Angeles. He died in 1906 doing what he did best, dispatching trains for the Missouri Pacific at Coffeyville, Kansas.

Frank Melbourne, a born gambler and con man, was known as the Australian

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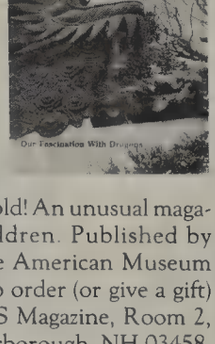

Rain Doctor. The newspapers were well supplied with accounts of the wonders the cloud manipulator had performed or was going to, and they obliged by calling him the Rain Wizard. His charge was $500 or $150, according to what the traffic would bear, and he guaranteed to produce rain in three days. Like most of the "precipitators" Melbourne promised "no rain—no pay," but there were ways of juggling the odds. Melbourne usually set up his apparatus at an agricultural fair where he released gases from chemicals he said were previously unknown to science. The theory was that drops of moisture coagulated around the particles of rising gas and came down as rain. If it rained in the wrong place, the professor explained that the wind had caused the gases to drift.

Sometimes rain followed Melbourne's demonstrations and sometimes it didn't, but the Rain Wizard's reputation was badly damaged when it became known that his secret equipment included a barometer and that the dates he chose for his performance coincided with the weather forecasts of a popular almanac widely respected for the accuracy of its predictions. Melbourne was a kind of shooting star—up and then out—the beneficiary of shrewd publicity and human gullibility.

Melbourne's career was profitable enough to inspire a school of imitators in Kansas and Nebraska: a former county clerk, a bank cashier, a "colonel" in New Mexico, a "professor" with a "powerful rain machine." There were also some imaginative cloud crackers whose activities were not necessarily chargeable to Melbourne's influence, though they may have found his success inspirational. A versatile Missourian named Dorman, who manufactured artificial diamonds, a laxative, and wrote poetry, brought forth the Continental Rain-Making Company and used both chemicals and a shotgun. A "doctor" with the improbable name of George Ambrosius Morrison Sykes, who believed the earth was flat, was, despite eccentricities, a salesman of such awesome capabilities that the *New York World* said he could sell the Brooklyn Bridge "without even getting up a sweat."

At Goodland, Kansas, a clutch of corporate entrepreneurs—franchisers, we would call them today—created the Inter-State Artificial Rain Company (which either purchased or stole Melbourne's "system"), the Swisher Rain Company, and the Artificial Rain Company. All of these opportunists could read the almanacs and the barometer and had access to the Signal Service weather maps. Like medical doctors of the period, rain doctors were not called in until the case was desperate. So a rain could reasonably be expected without human intervention. It was a bet the rainmakers often won. In case of a cloudburst, a lawsuit for damages would be no disaster but, rather, a great coup, since it would constitute legal proof that the pluviculturist did indeed make it rain.

The last and most spectacular of the producers of meteorological fantasies was Charles M. Hatfield, a former sewing machine salesman with a ninth-grade education. As a result of experiments conducted on his father's farm in San Diego County, California, Hatfield announced that a combination of twenty-three chemicals, properly aged and evaporated from galvanized pans on top of wooden towers or platforms, produced a "chemical affinity with the atmosphere." He explained his principle in vague but impressive jargon. One is reminded of Starbuck, the central character in the N. Richard Nash play *The Rainmaker*, who explains, "I look up at the sky and I say 'Cumulus!' I say 'Cumulus-numbus! Nimbulo-cumulus!'" Sure enough, after this bizarre incantation, rain came down "in buckets, rain in barrels, fillin' the lowlands, floodin' the gullies."

In addition to his use of scientific mumbo-jumbo, Hatfield also understood the persuasive power of understatement. "I do not make rain," he insisted. "That would be an absurd claim. I merely assist Nature. I only persuade the moisture to come down." It was, he said, "a mere matter of cohesive attraction." Since southern California is a semiarid region, the natural habitat of the road runner, the horned toad, and turkey buzzard, of sagebrush and cactus, the eternal search for water made Hatfield's evaporators a familiar sight. For nearly a quarter of a century he conducted some five hundred demonstrations, for fees varying from $50 to $10,000. His apparent successes made some southern California municipalities fearful that he couldn't put the genie back into the bottle, especially after a dam at Lake Moreno broke with heavy damage and loss of life. Sixteen inches of rain fell in two days. The city of San Diego offered to pay the rain magician's fee only if he would relieve the city of damage suits amounting to some $3,500,000. Obviously Hatfield chose not to collect and departed in considerable haste, well armed and without his $10,000.

At the high point of his career, Hatfield enjoyed the courtesy title of "professor," and he became something of a folk hero like Paul Bunyan or Pecos Bill. In recognition of his fame, the Native Sons of the Golden West erected a historical monument of red granite to "Hatfield, the Rain-

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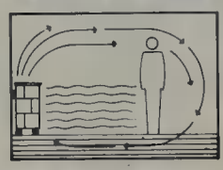

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maker" with an inscription describing the Moreno flood. When it was pointed out that the rainmaker's success was based upon knowledge of rain cycles, the use of weather charts, and delaying tactics until a drought was far advanced, the true believers pointed out that all great scientists had to bear the ridicule of the ignorant and the envious. Didn't they scoff at Copernicus and Marconi? Not until 1936, when Los Angeles drew Colorado River water from Boulder (now Hoover) Dam, did Hatfield's evaporators disappear from the California scene.

We reach the final, or at least the latest, chapter in the history of rainmaking through the concept of cloud seeding. In the 1920s a man named L. Francis Warren, often addressed as Dr. Warren be-

U.S. Air Force Photo

Dry ice pellets for seeding clouds are poured into a hopper on an Air Force plane.

cause of some unspecified connection with Columbia University, engaged the interest of a Cornell University chemist, Wilder D. Bancroft. Professor Bancroft, who held an authentic doctorate from the University of Leipzig, joined with Warren and the U.S. Air Force, which was interested in the military potential of weather control. Bancroft was attracted to Warren's idea that electrically charged sand particles sprayed from an airplane would bring down the rain. But the U.S. Weather Bureau countered Warren's enthusiastic press releases trumpeting uncanny successes; they declared that the approach was "picturesque and plausible" but "entirely futile." Electrified sand suffered the fate of all the methods that had preceded it: results were not conclusive. Statistical proof of effectiveness was lacking. The government lost interest and the necessary infusion of private capital never materialized.

Following the same idea of condensation nuclei, other theorists and inventors proposed various materials for sprinkling the skies—ammonia, carbon dioxide, sulfuric acid, chlorate of potash and Dry Ice, a trade name for carbon dioxide in a solid state. Arthur Brisbane, who wrote editorials for the Hearst newspaper chain during the reign of William Randolph Hearst, was able, because of his prominence, to go directly to President William Howard Taft, to promote liquid-air bombs and dust bombs. And some years later, still engrossed with the rainmaking idea, Brisbane proposed to President Warren G. Harding that powdered lime be dropped into the clouds. But the weather bureau pointed out that lime is a drying agent and the suggestion was filed.

More recent cloud-seeding attempts have been made with silver iodide crystals, notably by Dr. Irving Langmuir, the Nobel Prize-winner in chemistry, and his associate Vincent J. Schaefer. Together they worked on methods for de-icing aircraft wings during World War II. These investigations, according to Langmuir's biographer, Albert Rosenfeld, "led to controversial postwar experiments in seeding clouds for purposes of 'artifical rainmaking.' " It was in Langmuir's attempt to modify the weather "that he gained his most widespread celebrity."

In fact, controlling rain may not even be desirable; there are too many imponderables. Moving precipitation from one area to another produces no social benefits while possible risks include floods, erosion, more insect pests, and the proliferation of disease germs and noxious weeds. Or plant pathogens might flourish with changed conditions of temperature and moisture. Meanwhile a thorny legal question remains still unsettled: to whom does the weather belong?

Ultimately, the western farmer learned to adapt to a semiarid climate through irrigation, specially developed seeds, windmills, and the techniques of dry farming. So the rainmaker, with his smooth tongue and magnetic personality, a worthy analogue to the medical charlatan, faded from the scene, leaving a picturesque and slightly raffish footnote to American social and cultural history.

Gerald Carson, author and social historian, is a frequent contributor to Natural History.

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With the Grain

Throughout the Third World, it is the staple that defines the meal

by Raymond Sokolov

We talk, logically enough, about staple grains in our American diet. Wheat is certainly basic enough to the way we eat to qualify for this fundamental role in our nutritional patterns. It is rightly called the staff of life. Corn is its nearest rival and surpasses wheat altogether in the diets of Native Americans and Hispanics. And we all know that other cultures have based their cuisines on other grains: rice, oats, barley, millet, and so on.

The general notion of a staple is obvious. A staple is a basic source of food energy, a starch or carbohydrate eaten at virtually every meal. For most people, staples begin as grasses, whose seeds yield varying amounts of carbohydrate and protein, as well as other nutriments. But not all staples come from grains. The potato and the cassava plant (manioc) are the chief exceptions to the crucial role of edible grass in human survival.

But looking more closely at the specific ways in which individual cultures employ their staples, we can see immediately that evolved Western cuisines have moved some distance away from primary dependence on staples. For us, bread is the main form in which wheat comes to the table. At most, it is an accompaniment to the main dishes of a menu. Restaurants and cookbooks never list bread as a separate course. And many of us in this country eliminate bread entirely from our evening meals (although we eat masses of it as toast at breakfast or in sandwiches).

Even the more traditional French serve bread as an ancillary part of their meals. They, like us, fill their plates with animal protein, vegetables, dairy products, and all the other foods that modern agriculture can supply so dependably and with such delectable variety.

To replace starch with meat as the center of the meal is a sign of prosperity, a sign that a culture can afford to feed livestock with grain, quite inefficiently, instead of using it for human fodder. Italians have taken this step much like the rest of the industrial West, but they have held on to the pasta course as a starch-centered reminder of a more basic diet.

Ironically, pasta is now at the heart of the vogue of *nouvelle cuisine*. In three-star

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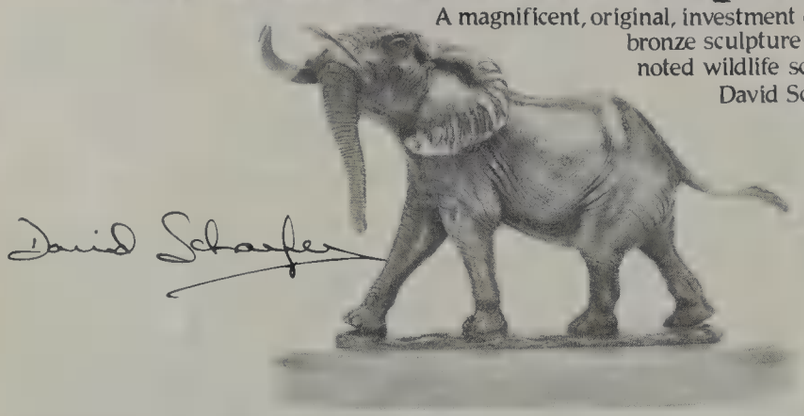

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French restaurants, you will be presented elite ravioli stuffed with lobster and floating on a refined sauce. No yuppie restaurant in this country would dare to write a menu without at least one exotic pasta concoction at the head of the list.

Nevertheless, I think few of the affluent customers in these modish establishments pause between forkfuls to reflect that they have reverted to the basic nutritional solution of the Third World. Pasta is, after all, nothing more than a convenient form of wheat, easy to store, shaped for quick cooking. In a typical pasta dish, the noodles form the overwhelming bulk and are flavored with a sauce normally composed of some more lavish form of protein and other flavorings to relieve the tedium of the basic mass of starch.

The simplest pasta I can think of would be tossed with oil and garlic and then sprinkled with cheese. More elaborate pasta dishes merely add other ingredients, without altering the fundamental notion: plenty of starch enlivened by smaller amounts of other foods.

This pattern, so rare in the Western diet as to be notable, is the normal structure of eating in the majority of households on the planet. Throughout the Third World, staple starches—not disguised by the relatively high technology that converts wheat to pasta or bread—are embellished with other food elements. But it is the starch that defines a meal.

China is the chief example. In his introduction to *Food in Chinese Culture,* K.C. Chang of Yale University wrote that the base of the Chinese dietary system is the division between *fan,* grains and other starch foods, and *ts'ai,* vegetable and meat dishes.

To prepare a balanced meal, it must have an appropriate amount of both *fan* and *ts'ai,* and ingredients are readied along both tracks. Grains are cooked whole or as flour, making up the *fan* half of the meal in various forms: *fan* [in the narrow sense, cooked rice], steamed wheat-, millet-, or corn-flour bread, *ping* [pancakes], and noodles. Vegetables and meats are cut up and mixed in various ways into individual dishes to constitute the *ts'ai* half. Even in meals in which the staple starch portion and the meat-and-vegetable portion are apparently joined together, such as in *chiao-tzu* [Chinese dumplings], *pao-tzu* [steamed bun with fillings], *hun t'un* [wonton], and *hsien-ping* [pan-fried bun with fillings], they are in fact put together but not mixed up and each still retains its due proportion and own distinction.

This parallelism carries through to cooking utensils, which are sharply divided between *fan* and *ts'ai* vessels. And, Mr. Chang says, the *fan-ts'ai* dichotomy

s so basic to Chinese thinking about food hat a Chinese cook presented with an American larder will produce a "Chinese" meal constructed according to the *fan-ts'ai* principle.

The universality of this principle has allowed Chinese to assimilate a wide number of staples in the *fan* category: rice, millet, *kao-liang* (a sorghumlike grain), wheat, maize, buckwheat, yam, and sweet potato. In our Chinese restaurants virtually the only *fan* we normally see is rice, but the basic principle is graphically illustrated when ethnic Chinese sit down at the table and deposit the *ts'ai* part of the meal on top of their rice, usually served in a separate bowl, and then consume the two types of food in combination.

Typical American diners in an American-Chinese restaurant often dispense with rice entirely. Waiters have learned to ask starch-averse Americans if they want to order rice. And even Americans who do order rice never think of it as the indispensable center of the meal. Like us, however, the Chinese, according to Mr. Chang, add more lavish amounts and kinds of *ts'ai* to their *fan* if they can afford it. The logical conclusion must be that the basic meal must have *fan* and whatever *ts'ai* can be scraped together.

This system of culinary thought, evolved from necessity, is alive in all the great rice-based cuisines of Asia. Hundreds of millions of people operate on the assumption that a meal is rice *and* something else. But the starch comes first and is always there.

In west Africa, this principle operates at its most basic. Millet reigns supreme; served as a porridge or in solid, dried "loaves," it is the "*fan*" of millions. The seeds of this nutritious grass are sold in the United States primarily for birdseed, but health food stores, impressed by millet's food value, carry it for human consumption. It makes an interesting alternative to rice or potatoes in a standard American meal. And serving millet from time to time is an easy way to give ourselves a taste of Africa (see recipe).

The taste of staple grains is, of course, extraordinarily important to the people who eat them every day. Rice connoisseurship in the Far East is not just a fetish of gourmets. Everyone cares about distinctions of texture and perfume. Rice may have become a staple grain because riziculture was practical for survival, but it is now so deeply a part of culinary life that it is impossible to imagine Asia without it. In the case of a rice famine, it would not solve the problem to ship wheat flour across the Pacific. Millennia of habituation to rice could not be easily wiped away by good

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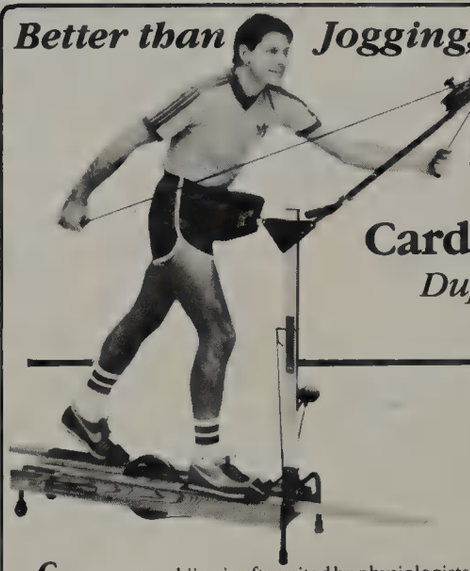

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At the very least, an immense effort of palatal and culinary reeducation would be required, with all the government apparatus and social control that such a complete disruption of normal life implies. This is exactly what seems to be happening in Ethiopia, where the authoritarian Mengistu regime is attempting to force the populace to accept the grain shipments sent by generous outside countries to alleviate the famine brought on by years of drought.

The problem in Ethiopia is especially severe. Added to the general conditions that have plagued the entire sub-Saharan Sahel region—bad weather, political turmoil, and primitive transport facilities—is the very special problem of Ethiopia's staple grain, teff.

Teff (*Eragrostis abyssinica*) is the cornerstone of Ethiopian culinary culture. Ground into flour, fermented, and then cooked like a large pancake, it is the basis for *injera*, Ethiopia's unique, flat, spongy bread. In a typical meal, the table is covered with *injera*, and other foods are arranged on top. Still other pieces of *injera* are provided, and diners pick up food from the table with torn-off pieces of the bread. After all the food has been consumed from the table, the *injera* that has been absorbing the juices is itself torn apart and eaten.

In Ethiopia, the lack of teff is a major political issue. On-scene news reports at the beginning of the summer indicated that most of the teff seed in Ethiopia had been eaten during the famine. And even though the rains had finally come, it looked as though farmers would have to plant sorghum and potatoes. Those were the seeds available from the outside, and many Ethiopians would be lucky if transportation could be found to bring even those undesirable seeds to them. But there was apparently nowhere at all to turn for teff seed.

Perhaps there are worse disasters than the disappearance of a diet based on a rare grain. In a generation or two, if the rains hold up and the four-wheel-drive trucks get through, Ethiopians will have forgotten teff and will have switched to sorghum *injera* or mashed potatoes. But a unique way of life will have been lost, unnecessarily.

Teff seed does exist, right here in this country. The drooping flower panicles of this plant wave in American gardens, where it is sometimes planted as an ornamental. The English-language vernacular name of the genus is "love grass," a direct translation of the Greek *Eragrostis*. Garden Magic Company (P.O. Box 6570, Zephyr Cove, NV 89449) sells the seed.

No doubt there is not nearly enough seed available right now to supply the needs of millions of Ethiopians. But there could be. If the U.S. Department of Agriculture promoted large-scale planting through subsidies and price supports in the time-honored manner, in a few years, American farmers could resupply Ethiopia with all the seed it needs to resume its traditional teff cuisine. In the end, a culture would be saved, and we would have an extremely powerful bargaining chip with which to exert benign pressure on the Mengistu regime for democratic reform.

Raymond Sokolov is a writer whose special interest is the history and preparation of food.

Tuo Zaafi

(West African millet dish adapted from Ellen Gibson Wilson's *A West African Cookbook*, Avon Books)

1 cup millet meal
½ teaspoon salt (optional)

1. Mix the millet meal with enough cold water to make a thin paste.
2. Bring 1½ cups water to a boil in a heavy pan, with salt if used.
3. Pour the meal paste into the boiling water. Lower heat so that the water barely simmers. As the mixture thickens, stir to prevent burning. It should take 15 minutes for the meal to expand fully and to soften to the consistency of porridge.
4. To serve, dip a large spoon into water and then into the *tuo*. Put a scoop carefully on each plate.

Yield: 1 to 2 servings

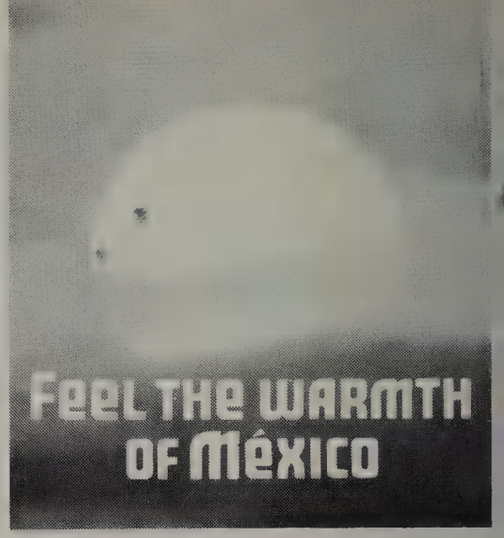
Sweet-Sour Millet

(Adapted from Adelle Davis's *Let's Cook It Right*, New American Library)

1 crushed bay leaf
½–1 teaspoon salt
1 cup millet
1 clove garlic, finely chopped
⅛ teaspoon ground nutmeg
2 tablespoons oil
2 tablespoons vinegar
2 tablespoons brown sugar

1. Bring 2 cups of water (or stock) to a boil in a heavy saucepan with the crushed bay leaf and salt.
2. Add millet in a slow stream. Reduce heat and simmer slowly for 15 minutes, uncovered.
3. Add remaining ingredients, stir, and simmer another 5 minutes, or until the millet is quite tender.

Yield: 4 servings



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After emerging from a night's rest in the ventilation shaft of a termite mound, a group of dwarf mongooses may spend a half an hour or so on their toilet before starting off on the day's foraging expedition. Hornbills, birds that frequently associate with mongooses, wait in nearby trees for the food search to begin.

J.B. Davidson

A Taru Life Story

In eastern Kenya, the dwarf mongoose forms an unlikely partnership with the desert birds

by O. Anne Rasa

Any list of mutualistic relationships would be heavily weighted toward the highly organized, impersonal world of the insects. The story of ants protecting and "milking" their cattlelike aphids, for example, is well known. Much less common is evidence of mutualism among warm-blooded vertebrates, and mutualistic relationships that cross taxonomic class lines, say, between birds and mammals, are especially rare. But in the Taru Desert of Kenya, I discovered just such a mutualism between the dwarf mongoose *Helogale parvula* and two species of hornbill. This relationship appears to be the closest known mutualism for any vertebrates and is comparable only to that found between ants and other insect species.

The Taru Desert is an enormous, flat area of semidesert bushland, dominated by the frankincense tree. It extends sixty miles inland from the coast of Kenya and stretches from the Tanzanian border in the south to the Somali border in the north. The region's only water sources are water holes, which are dry for more than half the year. From January to March, the hottest time of the year, temperatures reach 116° F in the shade. To survive, the animals that live permanently in the Taru must be able to obtain water from their food. Among the species indigenous to this harsh environment are the highly social dwarf mongooses and dry-bush hornbills.

Dwarf mongooses live in matriarchal families—in my study area there were about twelve animals in each group—and display a highly advanced degree of division of labor and altruistic behavior. Depending generally on its age and sex, a mongoose may serve the group by baby-sitting, attacking predators, driving away intruding mongoose groups, or acting as a guard to warn of a predator's approach. These roles, however, are not exclusive or permanent, and any group member can take over any of them as needed. Dwarf mongooses are also the only mammals, except humans, known to care for sick and injured members of the group. (Reports of such "nursing" behavior in lions, elephants, and dolphins have so far not been scientifically documented.)

The smallest of all mongooses, dwarf

Two dwarf mongooses, right, perch on top of a termite mound and stand guard while the rest of the group forages. Their task is to alert the group by repeating a loud warning call when raptors or other predators approach. When hornbills join a foraging group, below, the mongooses often employ fewer guards, taking advantage of the bird's ability to stop predators.

O. Anne Rasa

mongooses are almost entirely insectivorous. Unlike their more strictly carnivorous relatives, they feed mainly on beetles and grasshoppers, but mice and larger arthropods, such as spiders, scorpions, and centipedes, are a preferred part of their diet. Their preferences for grasshoppers and larger prey items overlap almost entirely with those of the two hornbill species with which they associate—the Von der Decken's hornbill (*Tockus deckeni*) and the yellow-billed hornbill (*T. flavirostris*).

The hornbills' family life, while not as gregarious as the mongooses', is also a tightly knit affair. Once mated, the birds stay together for several years. A close pair bond is important because during nesting—which may take place twice a year—the female is entirely dependent on her mate for her survival and that of their young. Hornbills nest in holes that they find in living trees. After the female has laid one or two eggs, she gradually walls herself in with a mixture of mud and feces, leaving only a small slit open to the outside. The slit is big enough to allow the male to feed her but too small to allow a predator, even a snake, to enter. While thus immured, the female molts all her flight and tail feathers and is unable to fly. Only after the eggs hatch and her new feathers have grown does she break down the protective wall and join her mate in provisioning the chicks. At this point, she usually has spent from six to seven weeks within the nest cavity.

The elder of her chicks immediately rebuilds the wall. As each chick matures, it, too, breaks out. With each breakout, the wall is rebuilt until each young hornbill has left the nest. Although the hornbill's social life differs dramatically from that of the mongoose, elaborate cooperative behavior characterizes both systems and may have aided the evolution of their mutualistic association.

The first time I encountered a group of mongooses foraging in the Taru Desert, they were accompanied by a large flock of birds. Von der Decken's and yellow-billed hornbills were present, as were the smaller red-billed hornbills (*T. erythrorhynchus*), white-crowned shrikes (*Eurocephalus anguitimens*), African drongos (*Dicrurus adsimilis*), and lilac-breasted rollers (*Coracias caudata*). As the mongooses wandered through the tussocky grass, the hornbills hopped behind or right in the middle of the group, while the other birds fluttered from tree to tree to keep up. Everywhere the mongoose group passed through the grass, grasshoppers, locusts, and moths flew up, only to be caught, usually in midair, by one of the birds. At first I thought the birds were simply stealing potential prey from the mongooses. Only after observing the animals and collecting data for months did I become aware of the true extent of the relationship.

I soon realized that the birds, especially the hornbills, actively sought the association with the little mammals. Dwarf mongooses generally seek shelter at night in the ventilation shafts of active termite mounds. The hornbills may have regular roosting areas, sometimes as much as a mile and a half away, but in the morning, they arrive and wait in the trees around the mound for up to three-quarters of an hour until the first mongoose emerges. The birds may then wait another half hour for all the mongooses to finish their morning toilet on the mound (a ritual that involves grooming, defecating, and marking territories with their scents) before starting off on the daily foraging expedition.

Such patience suggests that the wait is worth it. And the birds' arrival at the right termite mound suggests that they are very likely the same birds that accompanied the mongooses on the previous day. Because dwarf mongooses are nomadic—they may wander more than one-third of a mile per day and rarely spend more than one night in the same termite mound—it is likely that the birds rely on more than luck to locate the mound.

At times, the Von der Decken's and yellow-billed hornbills become agitated during the mongooses' morning ritual and actively attempt to hasten the mongooses' departure from the mound. At this point they adopt what I call their "chivying" behavior, which usually involves flying onto the mound, landing among the grooming mongooses, and walking demonstratively toward the base of the mound, where they wait briefly before repeating the process. This sequence continues until the mongooses leave. The birds may adopt a more extreme form of chivying if they have waited for more than an hour for the mongooses to emerge from the mound in the morning. In such a case, a bird flies down onto the mound, peers into the ventilation shafts, and calls, making a rhythmic "wok-wok-wok" sound. This approach gets a quick response; the mongooses ap-

O. Anne Rasa

pear immediately and leave the mound within four minutes.

But the mongooses are by no means passive partners in the association. They, too, appear to count on their morning rendezvous. Sometimes there are no hornbills waiting in the trees when the mongooses emerge from the mound because the birds have been disturbed in the early morning hours by predators or large herds of ungulates. More commonly, the disturbance has taken place the previous evening, driving off the hornbills before they could see where the mongooses had taken shelter for the night. In either case, when no hornbills appear, the mongooses are slow to begin the day's foraging, taking almost twice as long to leave the mound, even when other bird species are present. And if either Von der Decken's or yellow-billed hornbills arrive before the mongooses have given up and left without them, the mongooses then depart quickly: the longer they have waited, the faster they leave.

The advantage of the association for the two hornbill species is easy to understand: because hornbills and mongooses eat many of the same foods, hornbills can profit from the mongooses' foraging efforts. But the Von der Decken's and yellow-billed hornbills are not the only birds known to follow the mongooses. Why, then, has the mutualism evolved only between the mongooses and these two species? All of the other bird species are just as likely to forage in mixed-species bird flocks as they are to join a mongoose group. I have often seen these birds leave a group of mongooses to join a passing flock. Significantly, these other birds feed primarily on smaller insects; none includes larger prey in its diet. The two hornbills, in contrast, share the mongooses' taste for mice and large arthropods, and it is in competition for these items that they have the advantage. The mongooses are effective in finding and flushing a mouse, for example, from its hiding place in the grass, but if it escapes them, the more agile hornbills are more likely to make the final capture. Of all the birds, therefore, these two large hornbill species are the ones with the most to gain from associating with the mongooses. This may also explain why I rarely saw them when they weren't in the mammals' company.

Interestingly, hornbills never attempt to kill young mongooses, even though they are smaller than the rats that hornbills are known to catch and eat. On many occasions, I have seen a hornbill pick up a young mongoose that was begging for an insect held by an adult, fling the little mammal to one side, and then try to steal the insect from the adult mongoose's mouth. Most likely, the juvenile mongooses simply don't behave like prey—for one thing, they don't respond to the hornbills as raptors—but whatever the reason, hornbills show no inclination to kill the goose that lays the golden egg.

For the mongooses, the advantage of the association is based on protection from predators, especially birds of prey. The Taru is rich in raptors, not only in the number of species but also in the number of individual birds. It is also along one of the main migration routes for Palearctic and intra-African migrants. Mongooses spend about 18 percent of their foraging time hiding from avian predators. On average, a group is disturbed by raptors 12 times a day and attacked 1.3 times.

Many—but not all—of the raptors that prey on mongooses also prey on the hornbills. The hornbills' response to avian predators is straightforward: they explode into vertical flight and land in the nearest tree, where they hide among the branches while making very slow "wok" sounds. The mongooses have developed a more complicated, highly effective antipredator behavior. One member of the group—usually a subadult male—climbs to an elevated position in a tree or on a termite mound, from which it scans the surroundings while the rest of the group forages. Should it sight a predator, the guard warns the group by repeating a loud warning call; variations in the call indicate whether the predator is in the air or on the ground. On hearing the warning, the other members of the group run for cover—in termite mounds, in holes, under bushes, and in fallen trees.

Depending largely on how fast or slow the group is moving, as many as six guards may be present at one time: the slower the rate of foraging, the larger the number of guards. On average, guard duty lasts about fifteen minutes, but it may stretch to three-quarters of an hour. During this time, guards do not feed. Guarding is the most dangerous of the many roles played by the members of the mongoose group. The guards usually bring up the rear of the foraging group, and the only successful attacks I have observed on adult mongooses have been on guards running to catch up to the rest of the group, which may have wandered more than 250 feet away. The guard has to cover this distance alone and is thus especially vulnerable to an attack from the air.

The speed of the group, however, is not the only factor that determines the number of guards. I compared how many guards were present at any one time with the number of birds accompanying the group at that moment and was surprised to find a strong correlation: the more birds that are present, the fewer guards there are. With ten hornbills or more (I have seen as many as twenty-six), the mon-

Kenneth Fink; Bruce Coleman, Inc.

The yellow-billed hornbill, right and below, is one of several bird species that benefit from foraging with mongooses. As the little mammals work their way through the grass, they disturb a variety of insects and other arthropods, many of which are snatched up by the agile birds. Bottom: The smallest of all mongooses, the dwarf mongoose is primarily insectivorous, but it will prey on mice when the opportunity arises.

O. Anne Rasa

Bill Gabriel

gooses often go so far as to put up no guards at all, seeming to rely entirely on the hornbills to warn them of a predator's approach. When the birds spot a predator and give their warning, the mongooses run and hide, rarely bothering to utter warning calls of their own.

Such a system can work only if the hornbills warn of all mongoose predators, regardless of whether the birds themselves are at risk. (Although the two hornbills and the dwarf mongoose have many of the same predators to worry about, some raptors attack the mongoose but not the birds.) Many bird species have an inborn knowledge of what the raptors that prey on them look like; this enables them to flee at the first sight of an appropriately sized or shaped bird or even a shadow. If such knowledge is inborn rather then learned, I doubted that the hornbills would be able to recognize and respond to predators that threaten only the mongooses. And yet they do. Some of the Taru's raptors are too small (for example, the shikra, *Accipiter badius*) or too weak (the grasshopper buzzard) to capture hornbills, even young ones, which, by the time they emerge from the nest hole, are as large—if not larger—than their parents. Both these birds, however, elicit warning responses from the hornbills, and both kill mongoose young. The buzzard, the brown snake eagle (*Circaetus cinereus*), and the pale chanting goshawk (*Melierax poliopterus*) are the most dangerous mongoose predators.

Von der Decken's and yellow-billed hornbills are apparently also able to identify birds of prey that are not a threat to the mongooses. Neither the birds nor the mongooses are alarmed by the kestrel (*Falco tinnunculus*), the lesser kestrel (*F. naumanni*), or the red-footed falcon (*F. vespertinus*). These relatively small raptors are Palearctic migrants, and by the time they arrive in the late spring, the young mongooses are already too large for them to catch. Sometimes, kestrels and falcons even join the foraging group.

Thus, what appeared initially to be a fairly simple exchange of benefits—with the mongooses flushing food for the birds, in return for the birds announcing the approach of predators—has turned out to be a complicated mutualism of, most likely, long evolutionary standing. The mongooses' "commitment" to the relationship has led them to alter their guarding behavior—a highly effective (albeit dangerous to the individual guard) intraspecific defense against predators. The hornbills have had to learn to recognize and respond to raptors that do not threaten them but do threaten the mongoose, while at the same time passing up opportunities to attack young mongooses. Both bird and mammal benefit substantially from the association, and both have altered their behavior to a degree not previously reported for any social vertebrates involved in a mutualistic relationship. To survive the Taru desert environment, mongooses and hornbills seem to have adopted the motto: "Together we stand, divided we fall." □

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Mexico's colorful history and landscapes blend with your escape from winter. Archeological excavations, jungles, verdant coasts and dramatic mountain ranges. The Pyramid of Quetzalcoatl, Oaxaca, Mitla, Monte Alban, Palenque, Campeche, Uxmal, Chichen Itza, Merida. The anthropology museum of Mexico City. The gardens of Cuernavaca. Xochicalco. Zempoala. Puebla. Teotihuacan. $2,300. per person.*

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Celebrate Christmas and New Years sailing aboard the legendary tall ship, *Sea Cloud*. On deck with 36 sails set, you will enjoy an exhilirating experience no standard Caribbean cruise program offers. During the holidays join Museum lecturers for swimming, snorkeling and birding at ports-of-call which include Antigua, St. Martin, St. Bartholomew, Martinique, Barbados, Mustique and Palm Island. $5,290-6,890. per person.*

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Anthropology Tour to Morocco
March 21-April 5, 1986.
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Sept. 12-28 or Sept. 26-Oct. 1986.
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- ☐ **Archeology Tour to Mexico** Jan. 6-30
- ☐ **Egypt, the Nile and Ancient Culture** Feb. 9-March 1
- ☐ **Voyage through Melanesia: New Guinea to Fiji** Feb. 16-March 6
- ☐ **The Natural History of Hawaii** Feb. 19-March 4
- ☐ **Anthropology Tour to Morocco** March 21-April 5
- ☐ **Oriental Passage: Singapore to Athens** April 4-May 7
- ☐ **Trinidad and Tobago Wildlife Tour** April 14-23
- ☐ **French Castles and Caves** May 2-15
- ☐ **Art and Archeology Tour to Israel and Jordon** May 10-22
- ☐ **Amazon Wildlife Adventure** June 21-28
- ☐ **Alaska Wildlife Adventure** June 27-July 14
- ☐ **Voyage of the Vikings: Oslo to Dublin** August 12-28
- ☐ **Art and Archeology Tour to Tibet and China** August 16-Sept. 13
- ☐ **China: the Ancient Silk Route** Sept. 17-Oct. 10
- ☐ **Zambia, Zimbabwe and Botswana Safaris:** Sept. 12-28 or Sept. 26-Oct. 12
- ☐ **East African Safari** Sept. 25-Oct. 19
- ☐ **The Classical Mediterranean aboard *Sea Cloud*** Oct. 10-26
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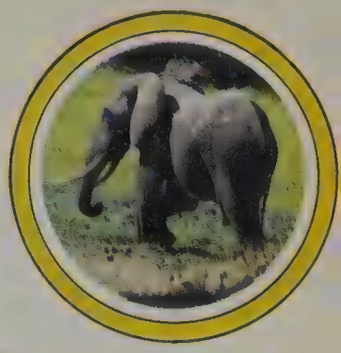

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Solomon Butcher's Pioneers

An itinerant Nebraska photographer captured a generation of sodbusters

by John E. Carter

It was land, raw and powerful and new, that brought people west. Solomon D. Butcher, an itinerant Nebraska photographer, captured the land and the homesteaders who settled it. A pioneer who photographed pioneers, Butcher left a legacy of nearly four thousand prints and negatives that bring us face to face with the generation that settled the vast prairie lands of Nebraska. Since 1912 these images have been accessible, a prized part of the research collections of the Nebraska State Historical Society.

When photography was invented, young America was beginning to stretch into the new trans-Mississippi West, and within ten years of the revelation of Daguerre's successful photographic process in 1839, image makers were pressing onto the frontier. Few pictures from this early period have endured, and we can only imagine the vision of the fresh world found by those who first photographed the lands of the Louisiana Purchase.

With the end of the Civil War, America once again began its westward exodus, and the government launched exploratory surveys into the vast reaches of the frontier. Before the Civil War, most surveys were accompanied by artists who recorded what they saw with pencil and brush. In the postwar surveys, cumbersome photographic equipment replaced the sketch pad in capturing the breathtaking plains, deserts, and mountains of the West. As railroads cut across the plains and snaked into the mountains, they, too, took photographers with them, recording not only the progress of construction but also the land that the tracks crossed.

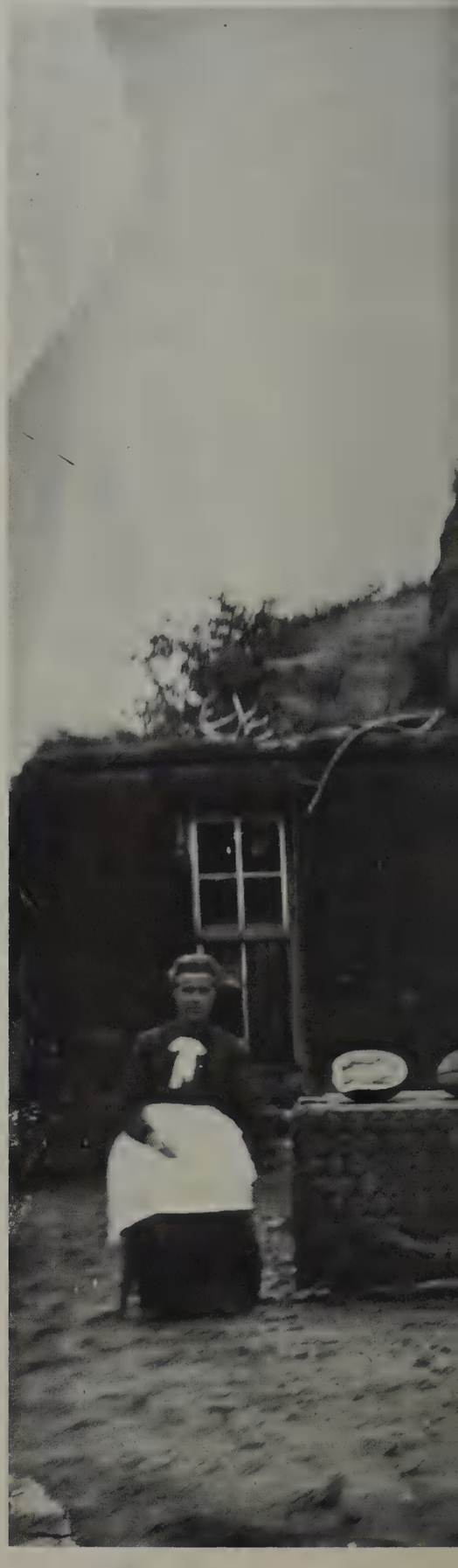
When, in 1869, the railroads completed the joining of East and West, the stage was set for a great experiment. Influenced by the Jeffersonian vision of a nation of yeoman farmers, Congress passed the Homestead Act of 1862 and the Timber Culture Act of 1874. This legislation, together with the sale at low prices by the railroads of the huge grants of land given them by the government, provided the means by which any settler could obtain a piece of land, a piece of the dream. The seductive advertisements of both the government and the railroads drew thousands west, offering a new promised land, a virtual garden of Eden.

Among the thousands who answered the siren call was Solomon D. Butcher. He was born in Virginia on January 24, 1856, the first child of Esther Ullom and Thomas Jefferson Butcher. In 1860 Solomon's father moved his family to Winona, Illinois, where he got a job with the Illinois Central Railroad pumping water for their locomotives. Young Butcher completed his high school education there in 1874 and for a time that year apprenticed to a tintypist and learned the art and science of photography.

In 1880 Butcher's father abandoned his secure job with the railroad to take a homestead in Custer County, Nebraska. Early in March 1880, accompanied by his father, his nineteen-year-old brother, and his brother-in-law, Solomon set out on the trek from Illinois to Nebraska, some seven hundred miles, in two covered wagons.

Seven weeks of travel ended when they arrived in northeastern Custer County, where Solomon and his father each took a claim. After determining that their claims had an adequate supply of water (an important concern on the prairie), they went to Grand Island, ninety miles southeast, to file for their properties in compliance with the Homestead Act.

When they returned to their claims, shelter became an immediate concern. Construction with sod (or Nebraska marble, as the locals called it) was not as simple as it might at first appear. The first trick was to locate the proper stand of grass that grew dense, dirt-holding root systems. A special breaking plow was used to cut the sod into long ribbons eighteen inches wide. These ribbons of sod were then cut again into three-foot lengths with a spade or corn knife, and the sections, three inches thick, were then laid like bricks to form walls. "My first experience in sod laying," reported Butcher, "con-



From *Solomon D. Butcher: Photographing the American Dream*, by John E. Carter. Copyright ©1985 by University of Nebraska Press. Reprinted by permission of University of Nebraska Press.

Posed in front of their sod house, a family of homesteaders faces Solomon Butcher's camera (1886). A family's possessions and livestock were as much a part of Butcher's images as the people themselves.

All photographs from the Solomon D. Butcher Collection, Nebraska State Historical Society.

sisted principally in wearing out my hands and my patience."

But Solomon rebelled at the thought of spending five years working a claim, as the Homestead Act required. After a two-week occupancy, he turned his land back to the government.

In the winter and spring of 1881–82 Butcher attended the newly formed Minnesota Medical College in Minneapolis. The experience did not result in a medical career, but it did introduce him to his wife-to-be, a young widow. Still restless, he returned with his bride to Nebraska. "I had seen just enough of the wild west," he later wrote, "to unfit me for living contentedly in the East."

Perhaps driven by the fear of returning to the physical life of farming, Butcher seized on an idea: he would produce a photographic history of Custer County. "From the time I thought of the plan," he said, "for seven days and seven nights it drove the sleep from my eyes."

But he had only the idea. His resources had long since been squandered in his moves and halfhearted attempts at homesteading. Butcher's father, however, had managed to make a comfortable life for himself. So Solomon asked his father for a team and wagon to transport the equipment necessary to make his photographs. His father was a "cautious man," and while the elder Butcher pondered the merits of the project, Solomon went to town and within two weeks arranged with seventy-five of the area's farmers to take their pictures for the history. This convincing initial response won both his father's blessing and the wagon, and thus supplied, Solomon began his enterprise.

Travel was complicated for Butcher; roads, if they existed at all, consisted of little more than ruts. He would journey for hours to reach the home of a family that he wished to photograph, and often he accepted food, lodging, and the stabling of his horses in exchange for a print. As he traveled, he supported himself with subscriptions and donations that various citizens made to the project, as well as by the sale of photographs. Over the next seven years he made some fifteen hundred images. Along with the photographs, he col-

Sod houses, built from the dense plains soil, were usually dark and cramped inside. In good weather, almost all activities took place outdoors. An extended family, left, lines up for a formal portrait, accompanied by their three mules (1888), and a group of men, below, engage in an open-air meal and card game (ca. 1886).

lected biographies and stories from the county's residents.

When it was finally published in 1901, the *Pioneer History of Custer County and Short Sketches of Early Days in Nebraska* ran for more than four hundred pages and contained eighty reminiscences illustrated with Butcher's photographs. The first edition of one thousand copies sold out before delivery that summer, and a second edition was ordered before Christmas. For once in his life Butcher tasted success.

Butcher's work has since become widely known. Scores of history texts have used his photographs of sod houses to illustrate the settlement of the Great Plains, and many of his pictures have made their way into books, films, and exhibits dealing with the American West.

S.D. Butcher has crept, almost anonymously, into the fundamental fabric of American thinking about the West. The fortunes of time and place were what created a number of the West's notable photographers. There were only so many government surveys and only so many railroads; fewer still were the number of photographers with a powerful aesthetic vision. It is therefore understandable why there were only a few William Henry Jacksons, Timothy O'Sullivans, and Carlton E. Watkins. But itinerant photographers like Butcher were common, for itinerancy was a fact of life for many western photographers.

Photography was not a lucrative profession. The economic fate of photographers was tied directly to the fortunes of the community in which they worked. If it rained and crops were good and prices up, people could afford photographs. If it was dry or crop prices were down, there was little interest in something as superfluous as a photograph.

Photographers facing these economic realities had limited choices. If the opportunity presented itself, they could also do contract work for the government, a railroad, or other major enterprises. Photographers could also try to produce pictures of interesting subjects that would sell outside their immediate market area, such as those of Indians, cowboys, or notable places or events. Another choice was to expand into fields such as pharmacy or patent medicine. The photographer could also go on the road and peddle portraits and other such images door to door. Most of these options forced photographers out of the studio and onto the road. Itinerancy was one method of breaking the downward economic cycle or at least forestalling it—a maneuver to extend the demand for photographic services.

Butcher's work has recently begun to capture the attention of art historians, and his photographs have been shown in prestigious museums and art galleries, but this is an alien environment for Butcher. Aesthetics was not a central concern for him, and anyone who has attempted to extract competent prints from his negatives will attest that he was not a technician of singular capability. Unquestionably he was not a prairie Stieglitz.

But if his method was not unique and his technical ability was merely adequate, how is it that his work has become so well known and widely used? It is significant

The subject range of the itinerant photographer was vast. Butcher might capture a gentleman out for a drive in his new car (1911) or take a humorously staged photograph on a Nebraska ranch (1903).

that Butcher was not primarily a portraitist. Because he was interested more in the settler's way of life than in the settler, he tended to step back and shoot whole homesteads. For him the house and possessions were equal in importance to the homesteaders themselves. In some of his photographs, in fact, the people in the picture are so small as to be rendered almost insignificant. What his pictures really deal with are states of existence. The houses and personal possessions serve as more than mere studio props. They are narrative elements that make a conscious statement by both the photographer and his subjects about the life that the subjects were living.

In my mind the significance of Butcher's work, then, is to be found in the statement that the photographer and the subjects make. There is a pride here that comes not from the accumulation of wealth but rather from being a part of history in the making. These people—the ones who came to settle the plains—came for land, to farm and ranch, to live that noble yeoman existence that Jefferson heralded.

I think Solomon Butcher was steeped in that significance. Certainly he knew of and revered Jefferson and his ideas, having been born in Jefferson's home state, the son of a man named for Jefferson. Moreover, he knew from intimate experience what the yeoman life meant, what the real worth of land was.

Some have looked at Butcher's work and seen in it lives of privation and suffering. It is, I think, because we like to make pioneers and settlers more than human, facing and overcoming all odds of man and nature. Perhaps there is a kind of severity that plains life etches into the faces of its people, but Butcher's people were, for the most part, neither hard nor in a state of suffering. Life may not have been easy, but neither was it desperate. These are not the faces of shattered lives, as pictured by Butcher's contemporary Jacob Riis; rather they are faces of hope, determination, and accomplishment.

In 1932 Jules Haumont, nephew of Gideon and Isadore Haumont, the men who built a palatial two-story sod house that Butcher photographed, said:

We came here to this beautiful country, in those early days, young, strong, healthy, filled with hope, energy and ambition. Poor, it is true, Oh! how poor in worldly goods, but rich beyond dreams, in everything that makes life worthwhile. I do not know how large a bank account some of the old settlers may have today, I do not care, they will never be as rich as I felt when I first settled on my homestead. I remember the time I did not have the money to buy a postage stamp. I remember the hard winter, the drought of 1894, the many obstacles to overcome. We came to win the battle, and

we did. To what amounted those inconveniences, compared to the joy we felt, when we turned the long furrows of virgin sod, or planted our first fruit trees. We were empire builders. The future was ours.

Because many of the pictures that Butcher made were more than portraits, a unique interaction resulted between photographer and subject. Images appear to have been set purposely like a stage. The subjects seem to assume stances that are symbolic and expressive. Some appear with jaw set and shoulders back; others with sweeping, master-of-all-you-survey gestures. In some instances people dragged their most precious possessions out to be photographed with them or rearranged equipment and livestock to be a significant part of the image. But this hauling out of prized possessions was not done as often as some have assumed. Sod house dwellers were fundamentally people who lived out of doors. A sod house was a shelter while they slept, a haven from storm, and a place to cook in the winter. The standard litany recited about sod houses is that they were warm in the winter and cool in the summer—and that is true, owing to their three-foot-thick earthen walls. But they were also dark and usually cramped. So when the weather permitted, almost all living activities took place outside. Many items, such as chairs, sewing machines, and stoves, normally associated with indoor activities, are found outside in the Butcher photographs. When the sod house era had passed, so too had this need for outdoor living. In his later photographs, which show frame structures, the clutter of outdoor living disappears.

The history that Butcher recorded was personal—one of individuals and not movements. Only one in three homesteaders stayed the five years required to prove up on their claims, and many of those who proved up would be forced out by later adversity. Therefore, each homesteading ex-

perience was an individual drama. The pride of survival is evident in the faces of Butcher's subjects; their gaze is arresting and their expressions electric with hope. Like other nineteenth-century photographers, Butcher engages his subjects directly. They face the camera squarely, photographed not in the act of doing but rather in a state of being.

In many of Butcher's photographs, people appear barely visible in doorways and windows or they stand so far in the background as to be hardly noticeable. In this way Butcher would often pepper his photographs with people, seemingly scattering them about the frame. This curious spatial arrangement tempts one to speculation. The proximity of person to person may be tied to kinship, with members of the nuclear family massed together and extended family members or hired help projected out elsewhere. It might be that such groupings are the result of subjects posing themselves (although that is unlikely, for only the photographer would know the scene's organization as the camera sees it). More than likely, however, these groupings are the result of Butcher's own eccentric aesthetic, combined informally with the desires of his subjects.

In most of his landscapes (of which there are few) Butcher placed a person somewhere in the distance. Perhaps he did so to indicate scale or to include a human element in the pictures that he made of the land, much as he put the land in the pictures that he made of people.

The interaction of human subject and the land bears close examination in Butcher's work. As a whole the collection reveals a great deal about the process of settlement—far more than the photographer had likely intended. This process is almost an evolutionary one: of people marking the land, dividing it. "Of all the bewildering things about a new country," wrote Willa Cather in *O Pioneers!* "the absence of human landmarks is one of the most depressing and disheartening . . . ."

It is here in a bewildering new country that the settlement odyssey begins. The first sod houses divided only the inside from outside. With typical eloquence Cather describes them as "only the unescapable ground in another form." In these preliminary dwellings people and animals share quarters; work areas are indistinguishable from living areas. Soon one witnesses the cropland becoming more distinct and living and working areas more defined. Fences segregate animals from humans, and outbuildings more sharply focus the various labors of agriculture. With the frame houses come yards and ornamental gardens, and the differentiation begins to move indoors. The frame dwelling offers more than the shelter afforded by sod houses, for it can provide privacy and an interior division of labor. Spaces within the house are dedicated to specific activities: eating, sleeping, socializing, and even storage.

With but little imagination we can see the process as one of bringing the horizons closer. From the collective level, that is what the legal division of land did, sectioning a continent into 100-mile-squares, and those into 160-acre, quarter-mile squares. Inside these quarter-mile squares individuals begin to define inside from out, animal habitation from human, working land from living space, and space inside the house itself. It seems a process of putting boxes in boxes, the "record of human strivings" to which Cather referred.

There is a sense of humor and a lack of preciousness in Butcher's photographs that I find refreshing, and yet these very qualities may exclude him from serious consideration by art historians. I suppose that it is just as well, for Butcher himself would be uncomfortable in such a company as that.

He really was just an average sort of fellow—a dreamer at that. We can, however, thank him for having the common sense to see the obvious. I often wonder whether, if he were alive today, he would be photographing mobile homes and fast-food restaurants. It is that kind of vision for which history, in hindsight, is grateful. "How well I have succeeded," he said in his *Pioneer History of Custer County*, "I will leave to the reader to judge after he has read to the last page and looked at the last picture, and hope you will always hold in kindly remembrance your humble servant S.D. Butcher." □

A settlement odyssey begins. The Reverend Peter Widvey, his wife, children, dogs, chickens, and mules pose below the unfinished sod house that was to be their home (1887). When Butcher took this photograph, the family was living in the little dugout visible in the upper lefthand corner.

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A Movable Feaster

A tiny, caterpillar-like carnivore has survived since all the continents were one

by Michael T. Ghiselin

In 1826 Rev. Lansdown Guilding published a description of a curious little animal from the Caribbean island of Saint Vincent. To him, it looked rather like a slug, but it was a most peculiar one, with many little feet. He named it *Peripatus juliformis* and created a new class of mollusks to receive it. This obscure creature has been the subject of scientific inquiry and debate ever since.

To most people, *Peripatus* looks more like a caterpillar or a centipede than a snail or a slug. Pre-Darwinian zoologists agreed that the resemblance to mollusks was superficial. Their evolutionist successors recognized the creature as a very primitive arthropod, illustrative of the early stages of adaptation to life on land and suggesting links between major animal groups. Peripatuses and their allies came to be classified as a distinct group called the Onychophora, a name that refers to the claws on their feet.

Today, they still occasionally provoke taxonomic controversy. Onychophora is sometimes treated as a separate phylum, sometimes as part of the Arthropoda (along with insects, crustaceans, and spiders). There is little doubt the phyla are related, but it is still being debated whether the onychophorans are closest to insects and centipedes or whether they branched off from the mainstream of arthropod evolution somewhat earlier. Fossils are of little use in deciding this issue; as with soft-bodied organisms in general, remains are few and hard to interpret.

Our growing understanding of continental drift in recent decades confirms the idea that the onychophorans are very old. The thirty or so known species fall into two natural groups. One group, which includes the genus *Peripatus* itself, occurs in tropical America, the Congo, and within and around the Malay Peninsula. The other group inhabits Chile, South Africa, New Zealand, Australia, and New Guinea. Since onychophorans can't swim across oceans, these two discrete groups must have evolved before the ancient supercontinent of Gondwanaland broke up. Even before that time a desert seems to have separated the northern and southern forms. Then, when the huge landmass

Photographs by Raymond A. Mendez

Peripatuses capture prey by shooting a gluey substance from openings on each side of the mouth. Below: After firing its glue, a collared peripatus draws back its head to break the sticky threads. Wartlike papillae, each with a sensory bristle, ring the animal's body and legs.

A collared peripatus closes in on a cricket, a favored prey item. Crickets are more agile than the slow-moving peripatus, but they are helpless against the predator's glue.

came apart, peripatuses drifted with the fragments, sometimes to within crawling distance of new habitats.

In the late nineteenth and early twentieth century, peripatuses and their relatives were very popular objects for evolutionary research. These animals were an old form of life, yet their anatomy seemed to have evolved very little. Indeed, for more than a century, they, along with the lungfishes and egg-laying mammals, have been viewed as living fossils. And because they have some characteristics of segmented worms and some of arthropods, they are one of the best cases of a transitional form, or nonmissing link.

For example, the peripatus's eye, at the base of each antenna, is more like the simple eye of a worm than the compound eye of an insect. Like higher arthropods, the peripatus has limbs, but these do not have

Stalking the Collared Peripatus

by Morley Read

When darkness falls, I set off through dense forest to my study site, a steep earthen embankment about 130 feet long. Offering numerous holes for daytime retreat, the bank is prime peripatus habitat. I scan the slope with my headlight; the night forest is alive with the sound and movement of bats, crickets, and frogs. Occasionally I glance at the path ahead to avoid an encounter with a fer-de-lance, one of the most venomous snakes in the area. For the past two years, I have studied peripatus nocturnal habits at the Simla Research Station in Trinidad, home of the largest species, the collared, or giant, peripatus (*Macroperipatus torquatus*). Its length (up to six inches), dark red body, and bright yellow collar make this species somewhat more conspicuous than its plain and equally reclusive relatives.

After an hour's search at the site, I spot the caterpillar-like animal trundling over the soil, its stumpy feet propelling it several inches a minute. The double claw on each foot enables the animal to grip and climb vertical surfaces. On an average night, one or two collared peripatuses will be visible, out of a population of about thirty—half of them adult females; the remainder, adult males and juveniles. Many simply stay in their burrows. Those that do emerge are usually well concealed by leaf litter and other damp forest detritus.

Although capable of walking many yards in a night, adult females maintain home ranges of a few square feet centered on one or more favorite burrows. Males, smaller and with fewer legs, roam in search of food and mating opportunities.

My study focuses on the feeding behavior of the collared peripatus. Witnessing a capture repays many long nights of watching. A carnivore, whose diet includes crickets, spiders, cockroaches, and assorted microfauna, the collared peripatus often attacks prey as large as, and nimbler than, itself. The first feeding I observed pitted the peripatus against a delectable but agile long-legged black cricket, *Aclodes*.

Whether lurking at burrow's edge or venturing out to hunt actively, the collared peripatus detects nearby prey by touch and smell. The creature's typical sluggishness now serves as stealth, and its dramatic defensive maneuver, shooting strands of glue from openings near the mouth, is put to aggressive use. At times when its approach is entirely undetected, the peripatus examines a potential victim with its antennae and sometimes rejects it. Glue is mainly protein, and its expenditure on overly large prey likely to escape or on tiny prey that yield little nutritional return is presumably not cost-efficient for the peripatus.

Glue squirting is instantaneous. Suddenly a cricket is lassoed with lengths of sticky thread. Struggling all but guarantees entrapment, as the prey's legs stick together, but if the victim continues to kick, a few small squirts will suffice to glue down any flailing appendages. (Twice as much glue is needed to disarm a fanged spider as for a cricket of similar size. In one case I observed, this tactic failed, and an exceptionally big spider ate the peripatus.)

With the prey safely subdued, the dining ritual begins. Using its spiky jaws, the peripatus repeatedly bites and pierces a soft spot in the prey's body and injects a potent saliva that, within ten to fifteen minutes, kills the cricket and renders its inner body soft and palatable. During the waiting period, the peripatus gobbles up as much expended glue as it can to regain valuable protein. When the feast is ready, the peripatus dismantles the cricket, methodically tearing apart the hard abdominal plates and extracting strands of flesh with a ratchetlike jaw action. Several phalangids, relatives of the spiders and the "hyenas" of the jungle floor, gather, eager to steal a piece of the kill. In several hours, only the cricket's exoskeleton remains, and the collared peripatus is satiated for another two weeks. By dawn, all traces of the encounter have been erased by scavengers.

Working its jaws into a soft spot between two of the cricket's thoracic plates, the peripatus pours in its lethal saliva. Within fifteen minutes, the potent injection kills the cricket and begins to dissolve its inner flesh.

Having pulled away the cricket's abdominal plates, the peripatus delves into the body to feed on the softened contents.

the characteristic joints of the limbs of hard-bodied insects. Most of the body of the peripatus is wormlike, being soft and flexible, but the beginnings of a hard exoskeleton—like that encasing the whole body of higher arthropods—is found in the paired claws on the tips of its feet. Its soft body, incidentally, permits the peripatus to maneuver adeptly under stones and leaves or through cracks into rotting wood, in search of moist places. Otherwise it would dry out.

Because it has so many transitional features, the peripatus is a good subject for studying how one group of organisms evolves into another. One pair of limbs has been modified into jaws, and the hard tips have become enlarged claws. Another pair of limbs, near its mouth, has been modified into an organ that can shoot a sticky substance as far away as six inches. The animal uses the glue— produced by a modified kidney—for defense and to capture small animals for food. This example illustrates how a new organ, such as the animal's glue producer, does not arise out of nowhere but evolves from a preexisting organ that is in the right place and is able to shift to a new function.

If there were a Hall of Fame for life forms, perhaps the thirty odd species of peripatuses and their relatives would be retired to rest on their many scientific laurels. But contemporary biologists are raising many new kinds of evolutionary questions about the onychophorans, especially about their reproduction.

Onychophorans may be living fossils, but they have evolved a range of internal reproductive systems that at one extreme are like those of a lizard; at the other, resemble those of higher mammals. Some onychophorans bear young that develop internally; others still lay eggs. At the most primitive end of the onychophoran reproductive scale, *Ooperipatus* lays shelled, yolk-rich eggs, which develop outside the mother's body. Interestingly, like the egg-laying mammals, *Ooperipatus* is found in Australia. Taken all in all, the various types of onychophorans form an evolutionary series in which the embryo comes to be nourished less and less by yolk and more by secretions from the mother. In the most advanced mode of reproduction, found in peripatuses and their close relatives, a tiny egg attaches to the uterine wall and forms a true placenta—an arrangement similiar to that of higher mammals. This is a remarkable case of convergent evolution.

In some onychophorans, gestation is very long—twelve to fifteen months is not unusual. Often the uterus contains a series

Peripatuses lose both energy and body weight when they expend glue. While the saliva is acting on the prey, the peripatus salvages protein by eating any used glue that it can recover.

Although peripatuses evolved millions of years before placental mammals, some species bear live young. Below: By contracting its body, a young peripatus has almost completely freed itself from the mother's genital orifice (at top). Right: Although there is no evidence of parental care, newborns usually remain with the mother for several days. Young are able to walk and eject glue immediately after birth.

of developing embryos of different ages. Females begin to reproduce long before they reach full size, and a large proportion of their bulk consists of developing young. Therefore these animals have evolved an elaborate system of prenatal care, without having changed much otherwise. The reason why this "living fossil" has been so conservative in most aspects of its ecology remains unknown, but the variety of its reproductive modes can be explained in ecological terms. The placental forms are found in tropical areas, where the climate is stable and the food supply relatively constant. Under these conditions, parent organisms can consistently provide offspring with food and can successfully raise young throughout the year. Egg-laying forms are found in temperate regions with markedly different seasons. Here, a parent may be more successful if it raises a whole clutch at once, during the limited time that food is plentiful.

Another interesting question, also related to reproduction, is the evolution of sexual dimorphism. In most onychophorans, females are considerably larger than males. One explanation may be that large females are more successful at reproduction, but perhaps small males are better at becoming fathers. In evolutionary theory, reproductive success relative to other members of one's species is all that matters. In other words, whatever helps an organism outreproduce its conspecifics will evolve in the long run.

For an animal that moves like the peripatus, the larger it is the more legs it needs (just as large trucks need more wheels). A comparison of various species of onychophorans reveals that the biggest animals tend to have the most feet. Both males and females are about the same size when born, but in species in which females are larger than males, females have more legs from birth. All this is indirect evidence that females have evolved a larger body relative to males. Large size allows females to carry more offspring. (Onychophorans are born rather large. In one study, a half-grown female already contained young ready to be born; these were half her body length.)

But what about the small males? The male contributes nothing but sperm to reproduction. Most often, he places a packet of sperm in the female's reproductive opening. In some South African onychophorans, the male injects sperm through the female's body wall into her bloodstream. In either case, the sperm accumulate in a storage organ and are kept until needed. One impregnation may suffice for the female's lifetime. With such an arrangement, the best way for a male peripatus to reproduce is to mate as soon as possible and not waste time growing. If he dies after mating, his sperm live on in the female. Indeed, male onychophorans are sexually precocious, and some may even be fertile at birth.

Something more must be going on with the small male, however; a larger male that lived longer could produce more sperm and copulate more often. There may be other advantages to being small. Perhaps the small male can crawl more easily among leaves and under stones to find a mate or a moist spot or to avoid a predator. An adequate treatment of the question of smaller males will probably involve a complex balance among the advantages and disadvantages of a given size in feeding, growing, surviving, reproducing, and other activities.

A relationship between size and reproductive strategy can be seen in other animals. Some actually change sex as they grow older, sometimes from male to female or vice versa. In a fair range of animals, the young start off as males and produce sperm. But when they grow large enough to make an adequate supply of eggs, they become females. In other animals, males monopolize mates by fighting. Various fishes begin and grow as females until they get big enough to win fights. Then they switch sex. The same basic principles apply to peripatuses, but instead of changing sex, males mature early and remain small, while females mature later and grow more. A similar pattern has been discovered in the viviparous surfperches of California. The young are born relatively large, and males, which are much smaller than females, are able to father offspring soon after birth.

Naturalists have been observing such peculiarities of reproduction for many years. Often they have been recorded as mere curiosities or attributed vaguely to some advantage for the species. With modern "sex-allocation theory," evolutionary biologists can explain such facts in terms of a few basic principles that apply to all organisms. Peripatus may be an exotic creature, but the truths that it exemplifies cast light on all the rest. □

Hungry for sugar, ants hover around a treehopper trio. Treehoppers feed on phloem sap and excrete sugary honeydew; ants tend them in order to collect it.

A. Wilkinson; Valan Photos

Sugar Nannies

What's good for honeydew-hooked ants is good for sugar-excreting treehoppers

by Catherine M. Bristow

J.H. Comstock, one of the leading figures in American entomology, once wrote, "Nature must have been in a joking mood when she made the treehoppers." Treehoppers—so called because most types feed on trees or shrubs, from which they launch themselves abruptly if disturbed—certainly are curious. Some look just like thorns. Others look like cartoon monsters from outer space. Many of them have weird-looking, overdeveloped pronotums, the structure that covers an insect's chest or shoulder region. Of course, not all treehoppers are striking. But even relatively drab species such as the ironweed treehopper, *Publilia reticulata,* have a remarkably rich repertoire of behaviors, many of which stem from their propensity to enter into alliances with other insects.

Many insects, including treehoppers, are commonly tended by ants. "Ant cattle" was the term Linnaeus used to describe them in 1766, and the behavior of ants around these herds has fascinated several generations of naturalists. The ants, and in the temperate zone this includes many species, seem almost nurturing: they patrol the area around their chattel for up to several hours at a time, aggressively driving off intruders and sometimes carrying the insects to better feeding spots. They often build small shelters over them to keep them dry during rainy weather. Ants have even been known to protect the eggs of some insects by storing them in their own nests during the winter. What do the ants get out of it? Mainly, access to sugar—which is continually excreted by treehoppers, aphids, and the other insects ants tend.

Casual observers of this phenomenon usually notice the ants, and from that perspective, treehoppers and other ant-tended creatures do seem like docile herds that are exploited at the whim of their masters. But recent studies, by myself and others, indicate that this is not entirely the case. Treehoppers have developed ways of exploiting ants in return, improving on the standard benefits. This reciprocal exchange of services between two species is called a mutualism. And the mutualism between ants and treehoppers is one of the most intriguing examples of cooperation in nature.

Ironweed treehoppers belong to the insect order Homoptera, which includes most other ant-tended insects such as aphids, scale insects, and mealybugs. All homopterans have mouthparts designed for piercing plant tissues and sucking up the juices. Although different species feed on different plant tissues, most of those that attract ants feed on phloem sap. Phloem is one of the plant's vascular tissues and is its pipeline for transporting nutrients from leaves to roots or flowers. The sap contains primarily sugars and also some amino acids. So while it supplies more than enough carbohydrates to meet a treehopper's growth requirements, it doesn't provide much nitrogen, found in protein or amino acids, which all animals need to build tissues and carry out many other physiological functions. Treehoppers overcome this problem with a strategy that's not particularly efficient but very workable: they simply eat more sap. This allows them to take in the requisite nitrogen and then excrete the extra sugar—along with water and traces of other compounds—as honeydew.

Phloem sap, the basis of maple syrup, can be very sweet. Even after being digested by treehoppers, it is usually 10 to 20 percent sugar. As a result, honeydew is a valuable food to many animals. Bees sometimes collect it instead of nectar and make honey out of it. Even humans have collected honeydew for food: the manna of the Old Testament may have been dried honeydew, and today people still gather *man*, or sugar lerp, in several parts of the world. Ants, however, are undoubtedly the keenest collectors of honeydew.

How do these sugar aficionados operate? An ant will approach a treehopper and stroke the insect's back end with its antennae. If the treehopper has any honeydew, it will usually respond to this stimulation by excreting a droplet, which the ant takes in its mandibles. The ant normally stores the liquid in its crop, an expandable storage organ. Usually an ant worker will continue "milking" treehopper nymphs until its crop is full. Then it returns to the nest and freely passes the honeydew to other ants.

However renewable or defendable this food source may be, ants don't get a free lunch. Ironweeds, and other treehoppers, do their feeding at host plants, and if they want honeydew, ants have to make a trip there. This means some time and energy must be expended in travel from the nest to the feeding site. Also, since treehoppers allow other animals to feed on their wastes, ants may have to spend time defending the resource. I have seen ants aggressively attack other insects that approached their sugar cattle. Most of the time this involved ants from other colonies, which were after some honeydew themselves, but it can also include predatory insects such as ladybugs. (An individual ant may be able to repulse an intruder on its own. However, an ant generally sounds an alarm in situations like these—secreting a pheromone that mobilizes nest mates. So it soon has help.)

Traveling to a food source and defending it take time and energy, and a number

Food is the main reward ants get from associating with treehoppers, but the latter receive a wide range of benefits. If ironweed treehopper mothers can attract ants to their nymphs, they can abandon the clutch early and go on to lay more eggs. The mother below is remaining with her eggs in an attempt to lure the formicine ants next to her to begin tending her young.

Raymond A. Mendez

of variables influence whether an ant colony will find it worthwhile to work a particular group of treehoppers. For example, the size of a treehopper colony (in this case, colony means the nymphs of one mother) and its distance from the ants' home nest are important considerations. So too are the nutritional needs of a particular ant colony. Energy foods like sugar may be able to sustain workers, but ant larvae need protein. Honeydew may be less important to a colony at certain times than carrion, small insects, or seeds.

As a result, ants modify their foraging behavior depending on circumstances. They may abandon treehopper colonies that are too small or too far away. Species of larger ants may also have standards different from those of smaller ants of what makes a treehopper colony worth exploiting. Generally, larger ants are pickier than smaller ones about getting bigger colonies of treehoppers and more sugar.

But ants have very little in the way of specialized adaptations that keep the mutualism going. Even something that might seem like an obvious adaptation—building shelters for their insect stock, for example–is less for the treehoppers than for themselves. A few ant species form permanent trails to trees that support large populations of sugar producers. But most ants are more opportunistic than this. Indeed, their main concession to their partners is that they rarely eat them!

For treehoppers, it's another case entirely. The benefits provided by the ants are much more important to their success, and they have invested much more in maintaining the association. The ironweed treehopper is a good example. I spent several summers studying this species in an old field in New Jersey, tracking the new generation of nymphs for the six to eight weeks of their development. The field is actually a farm that was abandoned thirty years ago, and the main plants growing there now are goldenrod, brambles, and wild rosebushes. But down in the wet meadows and around a local pond we find dense patches of ironweed plants (*Vernonia noveboracensis L.*), some of which have gotten to be six feet high.

Ironweed treehoppers develop into adults their first year and overwinter in hibernacula at the roots or bases of plants. When they emerge in May they move about, presumably searching for mates and feeding plants. They mate on the feeding plants, and the males disappear shortly after that. The females then begin laying their eggs.

Both the mothers and their offspring, I learned, receive several different kinds of benefits from ant attendants. The most important of these is protection of the young from natural enemies, for without ants young treehoppers are essentially defenseless—they can't run away or protect themselves. Indeed, even with ant protection, many fall prey to spiders and ladybugs. Tended by ants, about twelve treehoppers will survive out of fifty, the average size of an egg mass. Without ants, the survival rate is only about 5 to 10 percent. In a world that measures success in terms of the number of copies of genes an animal passes on to the next generation, this difference can be very important.

Young ironweed treehoppers gain two

Ants of the species Ectatoma tuberculatum *watch over, and milk, a herd of treehoppers in Trinidad. To collect honeydew, an ant approaches the nymph and strokes its back end with antennae. The treehopper may then excrete a drop of honeydew, which it holds in place until the ant takes it in its mandibles. Ants generally store food in their crops and share it at the nest.*

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other rather surprising advantages from ant care. First, they grow to be larger adults. And, unexpectedly, some ants enhance growth more than others. Nymphs tended by *Myrmica lobicornis fracticornis* and *M. americana*, both medium-sized ants, are 20 percent larger than untended nymphs by the time they become adults. By contrast, nymphs tended by *Tapinoma sessile*, a much smaller ant, end up only about 10 percent larger than their untended counterparts. Tended nymphs also develop faster. Again, *Myrmica* ants are more effective at speeding things up. They cut almost ten days off the normal fifty-day development period. We still don't know why ants should have this effect, but we speculate that the treehoppers may develop faster because they tend to spend more time on the tops of leaves when ants are around. This means they're out in the sun for longer periods, and Tim Casey, a researcher at Rutgers University, has suggested this could influence growth.

Whatever the reasons, it seems clear that treehoppers with ant guardians have an array of advantages over those without them. Quicker development for a nymph means it spends less time vulnerable to the vagaries of the weather or to marauding predators. And bigger individuals have a competitive edge. In most invertebrates, the female's adult size is directly proportional to her fecundity—or the number of eggs she can produce. Large individuals may also have a better chance to survive the winter, to avoid predators, and to obtain mates. And finally, since larger treehoppers produce more honeydew, they may be able to attract the largest and best ants to tend their young. Although these

A group of formicine ants converge on a ladybug that has come to prey on their ironweed treehopper stock. At a study site in New Jersey, ironweed treehoppers that were protected by ants had a higher survival rate and grew to be 20 percent bigger than nymphs with no care.

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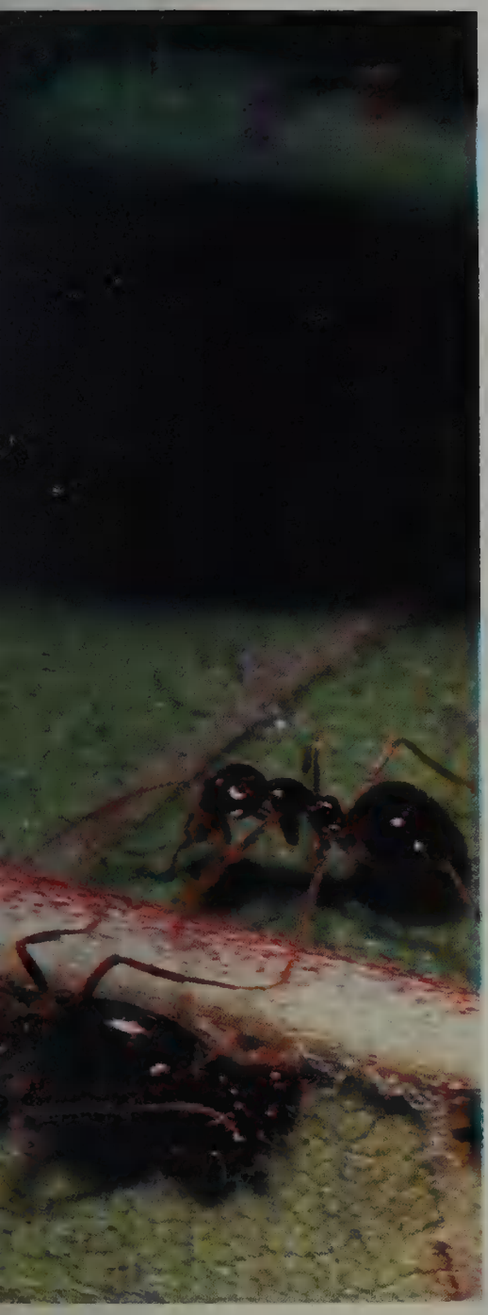
patterns seem to apply to *Publilia reticulata*, we will have to test them directly to know for sure.

Why ironweed treehoppers do better under the attentions of one ant than another also remains unknown. We know that ants can increase the growth and fecundity of aphids, probably by causing them to increase their feeding rate. A similar mechanism may be operating for the treehoppers. In any case, all of these differential benefits mean that treehoppers must not only have adaptations to insure ant attendants but they must also try to attract the best ants. This, I have found, is exactly what they do.

Obviously, the best way for treehoppers to draw in ants would be to increase their output of sugar. They do this primarily by aggregation, or living in groups. The first opportunity for aggregation comes early in the reproductive season, when females are choosing ironweed plants on which to lay their eggs. Females can be quite picky at this time, selecting only the largest and most vigorous stems. Using some cues that we do not yet understand, they will often congregate on stems, and many plants end up supporting two or even three colonies of treehoppers while others have none.

Such aggregation of colonies is the first step toward increasing the density of honeydew producers and thus the overall crop. Another strategy females use is to put all their eggs into one basket. Most female insects hedge their bets by laying their eggs over a variety of suitable sites. This not only reduces potential competition between offspring but also reduces the risk that all the young will fall prey to some calamity such as a predator destroy-



ng the entire colony or a large animal damaging the feeding plant.

Female treehoppers, however, generally deposit a single clutch of about fifty eggs in the midrib of a leaf. Laying such a large clutch guarantees that all the young nymphs will at least start their lives as members of a group.

The young nymphs also behave in a highly gregarious way. Newly hatched treehoppers are only about a millimeter long and are not capable of moving about to any great extent. As they grow, they normally pass through five molts, each stage being larger and more mobile than the last. By the third stage, or instar, nymphs are able to move to adjacent leaves. This reduces competition among them, for a single leaf would never be able to support all fifty nymphs through their six- or seven-week development period. But even though they are spread out all over the plant, the nymphs remain gregarious, usually feeding in groups ranging from a minimum of three, up to fifteen.

The instinct to remain with family members is very strong. An individual nymph can be marked and moved to another suitable plant about three feet away—a considerable distance to a creature that measures only about a quarter of an inch in length. Yet within twenty-four hours, the marked youngster will be back in the midst of its brothers and sisters.

A group undoubtedly serves to attract ants, since more treehoppers produce more honeydew. And the young treehoppers behave as if they recognize this basic principle. When attendants are present, the nymphs will eventually spread out over several leaves. But if ants are excluded from a dispersed colony, the young treehoppers will immediately reaggregate into one or two large clusters.

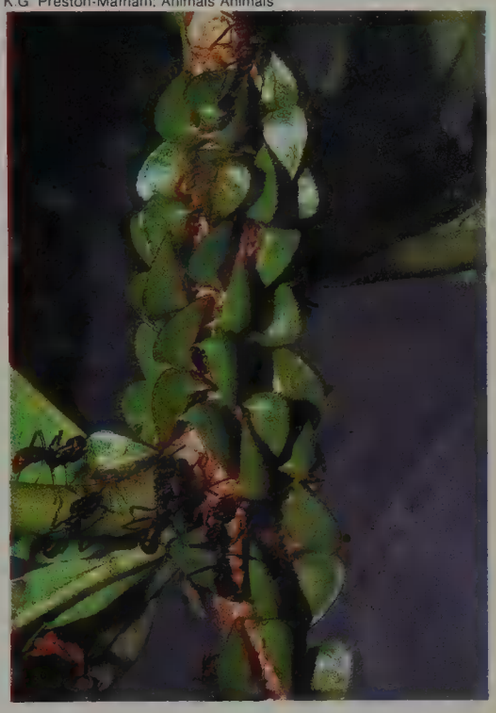
Another method ironweed treehopper mothers use to lure ants is to remain with their eggs after they are laid and even after they are hatched. This sort of maternal care is unusual for insects, except among the true social insects (for example, bees, ants, or termites). Why does a female remain? There appear to be two reasons.

The first reason is the obvious one—she is there to protect the eggs. Although ironweed treehopper females are not well equipped to deter large or determined predators, they do kick sharply at any intruders. A mother's care, when no ants are present, increases the survival of young from 3 to about 10 percent. This is still considerably lower than the 25 percent that survive under the protection of ants.

The other reason for staying is that a large female produces considerable honeydew in her own right and may attract ants during the period when the young themselves are not able to attract their own bodyguards—that is, before the eggs

Sensing a rich source of sugar, ants swarm onto a dense cluster of treehoppers in Trinidad. Treehoppers often aggregate, possibly to concentrate their total sugar output and make themselves more valuable to ants.

K.G. Preston-Mafham, Animals Animals



hatch, and when the young treehoppers are very small. Colonies that start out with a female in residence, I have found, are far more likely to be protected by ants throughout their development.

Females even seem to time their reproduction so they can attract preferred ants. Because ironweed treehoppers overwinter as adults they get an early start on their families and a longer growth season. But a second benefit is that the appearance of early colonies in June coincides with the period of peak activity of larger ants such as the two *Myrmica* species. These ants are, in general, more tolerant of cool temperatures; and by timing her oviposition to fall at this time, a female more than doubles the chances that her brood will be guarded by the best ants possible.

The adaptations that these treehoppers have evolved to attract ants are remarkable. However, there is more to the story, for ironweed females have developed the ability to modify their behavior to take full advantage of the surrogate mothering provided by ants.

Ironweed females are actually capable of producing several fifty-egg clutches, so in staying to care for the first one they are making a sacrifice. This cost is offset by the increased survival of the young. If ants

E. S. Ross

Aphids and scale insects, which also produce honeydew, are other insects with which ants form mutualistic relationships. The worker ant below is presiding over a batch of aphids, one of which is presenting its rear end—the classic posture prior to the excretion of a honeydew droplet. Treehoppers in the temperate zone are often dull looking, but tropical types are a wild collection of creatures. The group of spiny Guatemalan treehoppers, right, are sucking phloem sap.

Dwight R. Kuhn

are present to take up parental responsibility, however, the young will be adequately cared for and the female can depart. Indeed, this is what I have found she does. If no ants are present, the female ironweed treehopper remains with her young as long as any survive—on average, slightly more than a month. When ants are there, however, she abandons her offspring about six days after hatching begins. Thus females remain only long enough to insure ant attendance through the period when the young are not producing enough honeydew to attract ants themselves.

But what benefit does a female gain from desertion? Mainly she gains another chance to reproduce, for females that let the ants take over maternal chores go on to a new site and lay a second clutch of eggs.

For second, as for first, broods, females must balance the trade-offs between making the eggs attractive to ants and avoiding the danger of putting all their eggs in one place. Females achieve this by adopting a mixed strategy. About half lay their second clutch on another leaf of the same plant. This seems to happen particularly if they are not sharing the plant with any other mothers. The other half of the females move on to a new ironweed plant.

Producing a second brood on the same plant has inherent drawbacks, for it is the ultimate case of putting all your eggs in one basket. But there are several advantages, too; besides eliminating the uncertainty of finding another suitable feeding plant, the female gets automatic care for her second clutch. This is because the ants already caring for her first brood patrol the entire stem, and thus provide a ready-made protection service for the new clutch. And the females know this instinctively, for, as my studies have shown, rather than waiting until the nymphs are a week old, they desert these second clutches six days *before* hatching begins.

If the female moves onto a new plant to lay her second clutch she is essentially starting from scratch. And, once again, she behaves with fitting maternal solicitude—remaining with the newly hatched nymphs for more than a month if she fails to attract ants, or departing after a week if she succeeds.

A female treehopper, then, shows a remarkable—though totally instinctual—grasp of her situation. She can make the most of a wide range of circumstances by staying flexible in her behavior. This range of responses insures that she will produce the most young with adequate care and that they will have a good chance of being tended by the best available ant "nannies." □

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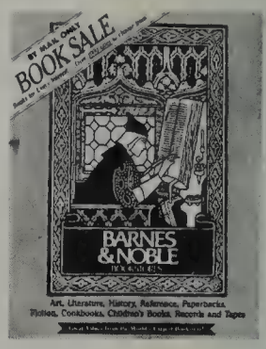

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Legacy of Ancient Indians

by Nancy Oestreich Lurie

Anthropologists use the term Woodland in more than one sense. Such is the case with *Ancient Art of the American Woodland Indians*, the catalog for an exhibit produced by the Detroit Institute of Arts. The title refers to a geographic area bounded roughly by the Atlantic Ocean on the east, the Saint Lawrence-Great Lakes waterway on the north, the Mississippi River on the west, and the Gulf of Mexico on the south.

Ethnologists, who work with living peoples, developed the term to classify the broadly similar cultures adapted to the Woodland region at the time of and since European contact, in contrast to the Plains, Northwest Coast, or other geographic culture areas. Archeologists use Woodland in a limited, temporal sense as a period of distinctive cultural characteristics occurring between, and to some extent overlapping, the Archaic (ca. 8000–1000 B.C.) and Mississipian (ca. A.D. 100–1600) periods. The artifacts depicted and discussed in this book come from the Woodland geographic region and were specially selected for their outstanding workmanship and beauty. They include ritual, ornamental, and utilitarian objects of clay, stone, mica, copper, shell, and wood from the Archaic, Woodland, and Mississippian periods.

The exhibit opened at the National Gallery of Art in Washington, D.C., this past spring, is appearing at the Detroit Institute of Arts this fall, and will end its run at Houston's Museum of Fine Arts in the winter of 1985–86. Long after the exhibit is dismantled, this catalog will serve as a valuable reference, as well as a visual delight. Thanks to the magnificent photographs by Dirk Bakker (including fifty-

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ANCIENT ART OF THE AMERICAN WOODLAND INDIANS, by David S. Brose, James A. Brown, and David W. Penney. *Harry N. Abrams, Inc., in association with the Detroit Institute of Arts, $35.00 (hardcover), $20.00 (paperback); 240 pp., illus.*

Ceramic nursing-mother effigy bottle, Mississippian period, A.D. 1200–1400

Saint Louis Science Center

two full-color plates), one can almost feel the shape and texture of the artifacts. Maps further enrich the presentation, as do reproductions of drawings made by Europeans at the time of contact and photographs showing the sweep and grandeur of ancient earthworks as they appear today.

The objective of both the exhibit and the catalog is to promote recognition and appreciation of the prehistoric art of the North American Woodland area. Given the powerful testament of these compelling objects and artifacts, the question arises, why have the artistic traditions of this region been so long overlooked? A partial answer, supplied in the preface by Michael Kan, is that it was not until the 1930s that American Indian objects in general began to be appreciated for their artistic appeal. Kan's discussion of exhibits of Indian art over the past fifty years concentrates on ethnographic rather than archeological materials, but even the more recent appreciation of the artistic worth of archeological specimens has emphasized the Southwest, particularly prehistoric pottery.

In my opinion, historians and the art-oriented public have neglected prehistoric art in eastern North America mainly because archeological work in this area has long been concerned with cultural and historical reconstruction in general. For the nonarcheologist, these studies are pretty dull going. Myriad potsherds and projectile points must be submitted to intensive quantitative analysis for evidence of migrations, relationships, and trade. Painstaking excavation and plotting on paper of changes in earth strata and evidence of post holes, hearths, and middens must be carried out to learn about the size and nature of settlements, dwellings, and domestic arrangements. The mundane facts of everyday life in the successions of ancient sociocultural systems necessarily dominate the archeological literature. Those objects on which exquisite effort was lavished, and which can properly be designated as art, can only be fully understood against this background. For those who want to learn about the people and the circumstances that produced these artifacts, this volume is an excellent introduction.

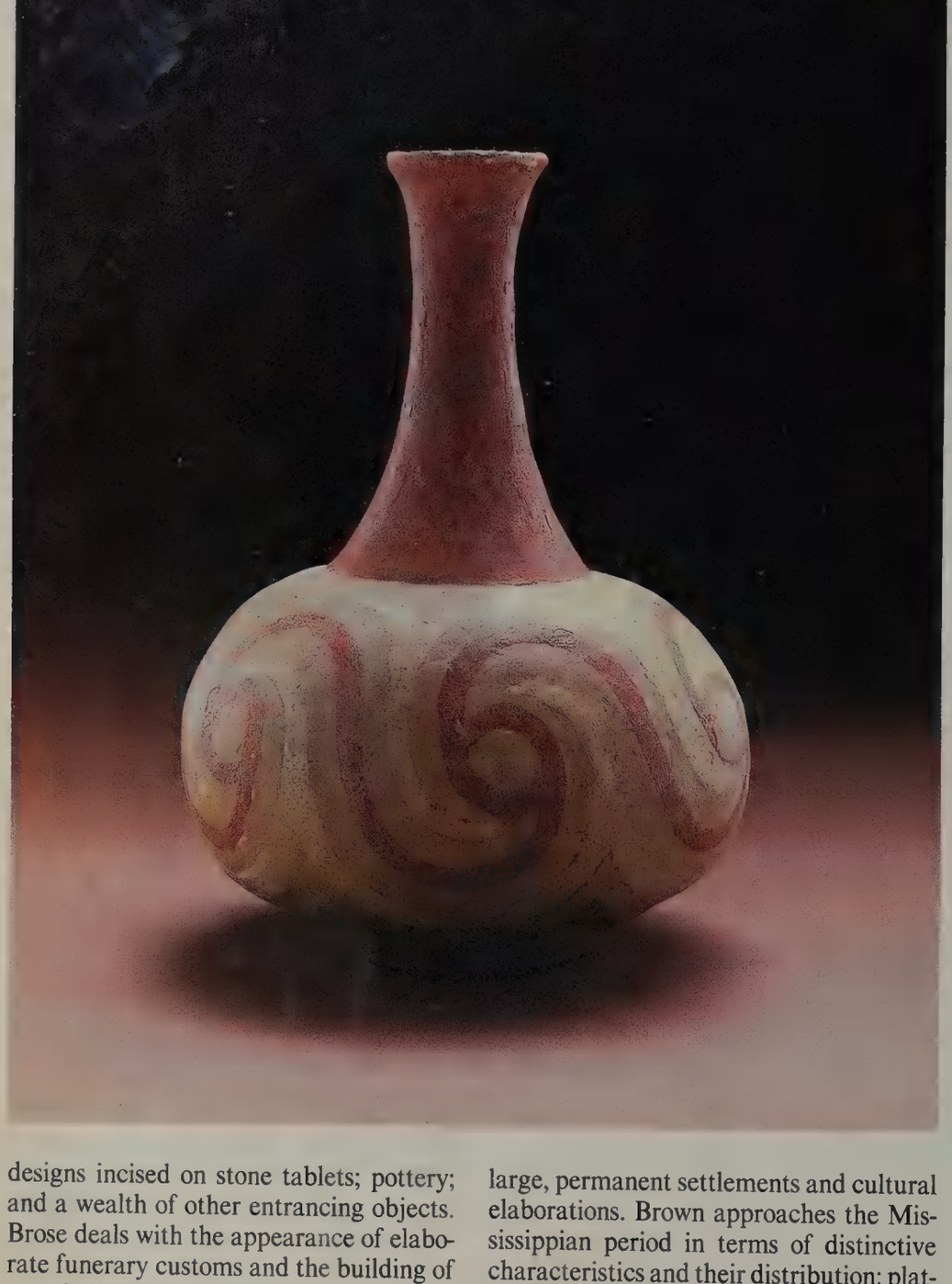
After an introductory overview, David Penney discusses the Late Archaic period (ca. 3000–1000 B.C.), with a glance back at the beginnings of human habitation in the area, known as the Paleo-Indian period (12,000–8000 B.C.), and the Early and Middle Archaic periods. The latter were characterized by small roving bands using a wide variety of foods—big game, smaller animals, waterfowl, and many edible wild plants—whereas the Late Archaic shows the development of relatively large settlements along river valleys and more specialized exploitation of local ecological conditions. There is evidence of intergroup hostilities but also of extensive trade over long distances. During the Late Archaic, rattles, flutes, and smoking pipes make their first known appearance in this part of North America. The chapter is illustrated with characteristic ground-stone implements and copper artifacts of pleasing symmetry and remarkable beauty. Less familiar Archaic items included in the exhibit are exquisite effigy beads of red jasper in the form of owls and a locust.

The Woodland period is detailed by David S. Brose, curator of archeology at the Cleveland Museum of Natural History. At one time archeologists thought that a sharp distinction could be made between the end of the Archaic and beginning of the Woodland period, but there seems to have been a fairly easy transition from egalitarian bands of hunters and gatherers to more settled peoples with more complex social organization. By about A.D. 500 the Woodland period took on distinctive characteristics. The presence of pottery is the definitive marker of this period, increasing in importance and proliferating into a variety of localized styles as the period wore on. Agriculture also first appears in the region during this time. It is still unclear when plant domestication began, but it may have started in later Woodland times with native plants giving way to maize cultivation introduced from farther south.

Early, Middle, and Late Woodland cultures in their various localized manifestations are discussed and illustrated in terms of effigy pipes, cutouts of birds and other natural forms in mica and sheet copper;

Banded slate bannerstone, Late Archaic period, 2000–1000 B.C.
The Gordon Hart Collection; Bluffton, Indiana

Ceramic bottle, Late Mississippian period, A.D. 1300–1500
Thomas Gilcrease Institute of American History and Art, Tulsa, Oklahoma



designs incised on stone tablets; pottery; and a wealth of other entrancing objects. Brose deals with the appearance of elaborate funerary customs and the building of round, linear, and effigy mounds in the Woodland period. The relatively familiar Hopewell Culture art is well illustrated, but artifacts from other Middle Woodland cultures show that outstanding artistry was not confined to Hopewell.

The Mississippian period, described by James A. Brown, professor of anthropology at Northwestern University, was clearly based on the trilogy of corn, beans, and squash, allowing the development of large, permanent settlements and cultural elaborations. Brown approaches the Mississippian period in terms of distinctive characteristics and their distribution: platform mounds to support structures, style regions in the Southeast, ancestor cults, the iconography of chiefs, serpent and fertility cults, and the design motifs of the serpent and the skull. Brown's chapter returns to the basic theme, the neglect of the region's prehistoric art. For a long time scholars tended to dismiss Mississippian art as a kind of derivative, poor relation of the art of Mexico. The materials assembled for the exhibit demonstrate that the Mississippian peoples had a vigorous, i digenous art tradition worthy of study an appreciation on its own merits.

As in the other chapters, the illustra tions speak volumes: incised shells wit complex motifs; the recurrent representa tions of the falcon man, the human hand and serpents; decorative effigies on pipe and bowls or free-standing figurines in th form of people, animals, and birds, bot real and mythic; and painted polychrom and incised pottery vessels. Since the cu tures of the Mississippian period per sisted—in some form, at least—lon enough into the early phase of Europea

Hand-shaped mica cutout, Hopewell culture, Middle Woodland period, 200 B.C.–A.D. 400

Ohio Historical Society, Columbus, Ohio

ntact to be noted in the written record, it possible to draw some confident conclu-ons about the function and meanings of any of the Mississippian pieces in the ex-bit. For example, observations by six-enth-century Spanish chroniclers help identify prehistoric stone figurines as presentations of founders of ancestral lts.

The final chapter by Penney, "Continu-es of Imagery and Symbolism in the Art the Woodlands," picks up the story om the Late Archaic to the present. An t historian, Penney discusses the appar-t function of many artworks as "primi-tive valuables," produced to establish and symbolize trading contracts rather than for practical physical use. Some objects appear to have functioned primarily as mortuary offerings.

Although at this time we have no absolute evidence of direct ties between historically known tribes and particular archeological findings, there is no question that the eastern tribes the Europeans met were the descendants, both physically and culturally, of the peoples known to us only archeologically. Drawing upon ethnology and motifs depicted on ethnographic specimens, Penney concludes:

It is fair to assume that Native North American religious practices and beliefs underwent a great deal of change during some three thousand years of history. However, the raw materials of religious thought, the basic world view—or at least the system of visual metaphors used to describe the cosmos—remained surprisingly consistent over the same period of time.

Nancy Oestreich Lurie is curator and head of the Anthropology Section, Milwaukee Public Museum. She is a cultural anthropologist with a special interest in North American Indians, ethnohistory, and museum studies.

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Nelder Grove, California

by Robert H. Mohlenbrock

When the naturalist and philosopher John Muir was locating and inventorying the stands of California's giant sequoias during the early 1870s, he came upon a handsome grove a few miles south of the now famous Mariposa Grove of Yosemite National Park. As he wandered through the pristine forest, which was bisected by a placid, picturesque creek, he was startled to come upon a small, well-constructed log cabin. In front of it, perched on a bark stool, was an old and heavily weathered pioneer. Several years later, Muir recalled his encounter with this former, mostly unsuccessful gold prospector:

> The name of my hermit friend is John A. Nelder, a fine, kind man, who in going into the wood has at last gone home; for he loves nature truly, and realizes that these last shadowy days with scarce a glint of gold in them are the best of all. He bade me welcome, made me bring my mule down to his door and camp with him, promising to show me his pet trees.

Today, this sequoia grove and the creek that runs through it bear Nelder's name; they are part of Sierra National Forest.

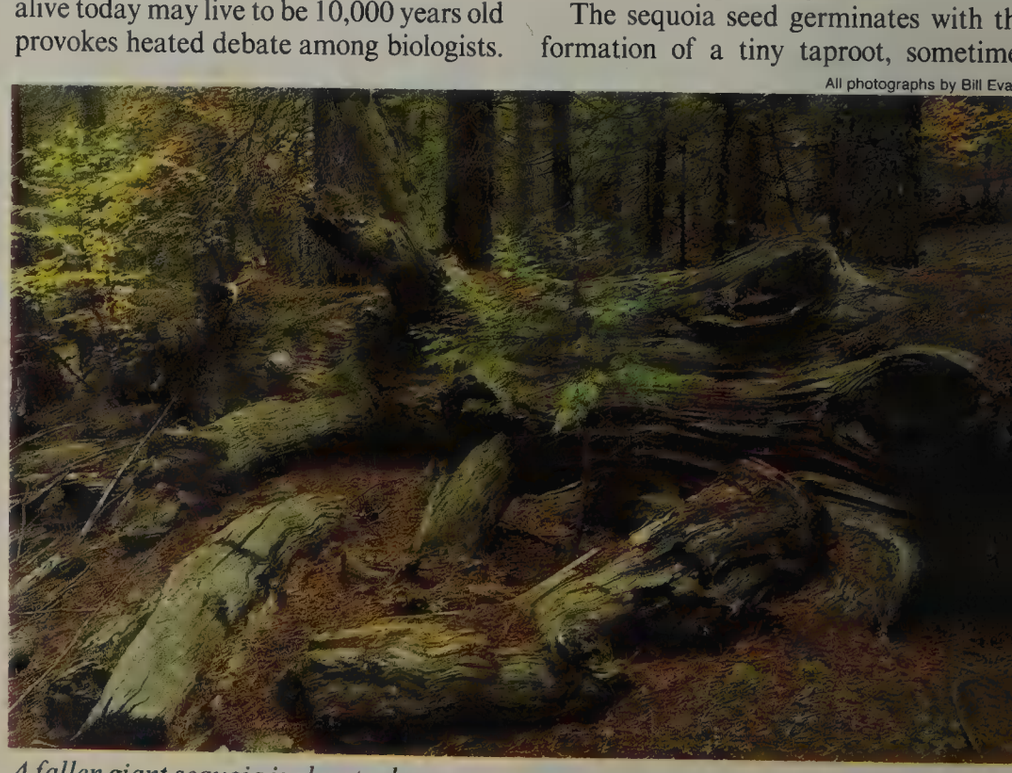
Giant sequoias, whose diameter may reach thirty feet and whose height approaches three hundred feet, are the largest living things in the world. The redwoods of coastal California and southern Oregon are taller, but they lack the great girth of the sequoias. Both trees belong to the family Taxodiaceae, which also includes the swamp-inhabiting bald cypress of the southeastern United States. Giant sequoias have thicker, redder bark and more sharply pointed leaves than the redwoods. Another difference is that redwoods are able to sprout from their stumps, while sequoias cannot.

The sequoias' gigantic size can be attributed to their longevity and the ample supply of moisture and nutrients where they live. Unlike animals, most plants continue to grow throughout their lifetime. If moisture and nutrients are plentiful, they may grow rapidly. Sequoias survive fires because their soft, spongy bark is up to two feet thick. The wood itself is decay resistant, making the trees less susceptible to damage by insects and fungi (even fallen sequoia logs may remain intact for hundreds of years before beginning to show signs of deterioration). Thus the trees can live to ripe old ages, growing taller and thicker each year. The General Sherman Tree in Sequoia National Park, apparently in its prime of life, is probably nearly 3,000 years old and still going strong. Speculation that some sequoias alive today may live to be 10,000 years old provokes heated debate among biologists.

A sequoia usually doesn't begin to for cones until it is at least 125 years old. C average, a mature tree produces son 1,500 cones per year. Each cone tak about eighteen months for its 150 to 3 seeds to mature, and the seeds may not shed for as long as twenty years. The livi part of the seed is only about one-quart inch long, yet it has the potential of de- oping into a tree that may contain 50,0 cubic feet of vegetable matter. Approx mately two-thirds of the seeds are abno mal, and one-fourth of the rest are likely be damaged by the Douglas chickaree reddish squirrel) and other animals. Th seeds that do germinate successfully r main in a precarious position, since desi cation of the soil during a seedling's fir few years will probably cause it to die.

The sequoia seed germinates with th formation of a tiny taproot, sometim

All photographs by Bill Eva



A fallen giant sequoia is slow to decay.

Joe Le Monnier

Nelder Grove

For visitor information write:
Forest Supervisor
Federal Building
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while snow still covers the ground. After a few years, the taproot is replaced by an extensive network of feeder roots that eventually may extend outward as much as 300 feet and cover three acres. The bark remains gray until the tree is about twenty years old; then it takes on its characteristic fibrous texture and rich red color.

For the first 150 to 300 years of its life, the giant sequoia is shaped like a Christmas tree, tapering to a graceful, pointed top, but as the years progress, the branching pattern results in a broadly rounded top. Because of its great height, the giant sequoia is vulnerable to lightning strikes, which may knock out part of the crown. Many old trees also exhibit "snag-tops," which are dead branches in the crown. They result when ground fires damage part of the water-transport system within the trunk, cutting off the supply of water to the affected branches high up the tree.

Nelder Grove is one of seventy-five distinct stands of giant sequoias that dot the western slopes of the Sierra Nevada for nearly 250 miles, from about twenty miles west of Lake Tahoe south to within forty miles northeast of Bakersfield. My first hike through Nelder Grove's tranquil Shadow of the Giants Trail came less than an hour after I had been jostled in a crowd of tourists as we were bused in and out of the Mariposa Grove in Yosemite. Mariposa Grove is parklike, with trees that have never felt the woodsman's ax and an understory kept clean through the removal of brush and the trampling by thousands of visitors each year. Beneath the tall trees in Nelder Grove, in contrast, is a dense growth of small trees, shrubs, and wildflowers that would be difficult to traverse were it not for the hiking trail.

Within two decades after John Muir had chanced upon his hermit friend, about half of the giant sequoias in the grove were cut off as much as twenty feet above the ground, and the great tops of the trees crashed to the forest floor, often splintering into uselessness. Giant limbs and huge stumps were left in the forest by the lumbermen who destroyed one-third of the giant sequoias in the nation between 1880 and 1930. Fewer than fifty mature sequoias were spared in Nelder Grove.

The trees that fell, either through natural causes or people's destructive for and the dense, brushlike vegetation ensued, provided fuel for fires, which u der natural conditions rage through quoia groves as often as five times ea century. Trees that grow with the quoias, such as white firs, sugar pines, a incense cedars, are able to survive only few of these fires, but sequoias, with th thick, asbestoslike bark, show only bu scars after a fire and are seemingly only little the worse for wear. A sequoia mo than 2,000 years old may have felt t heat of one hundred fires in its lifetim but it continues to grow and reproduce

As long as sequoias, firs, pines, and c dars—all capable of growing taller th 200 feet—live unmolested in a grove, th create a thick canopy that little sunlig can penetrate. In addition, their masses fallen leaves accumulate on the fore floor. Under these conditions of den shade and heavy ground litter, sequo seeds will not germinate. This is true Mariposa Grove, where lumbering h never occurred and where fire has be suppressed since the establishment of Y semite National Park. Ironically, the e fort to protect such mature stands of s quoias has threatened their regeneratio

But where sunlight pours in and the so is scarified by fire or human disturbanc sequoia seeds may germinate and develo into saplings. Nelder Grove is such place. There hikers can see trees that a less than 100 years old, a new generatio of future giants.

"This Land" highlights the biologic phenomena of the 153 U.S. national fo ests. Robert H. Mohlenbrock is disti guished professor of botany at Southe Illinois University at Carbondale.

Nelder Creek, above. The 2,700-year-old Bull Buck tree, right.

To the Spirit of the Oo

by Marc Breslav

Just beyond the rim of Maui's highest crater, Stephen Mountainspring rediscovered the Bishop's oo in a Hawaiian rain forest. The species, *Moho bishopi*, was last sighted in 1904 and had been presumed extinct by most authorities until 1981, when Mountainspring spotted it on the windward slope of the immense Haleakala crater. It had also never been seen with assurance on Maui and was known historically as a bird of Molokai. However, the two islands were joined until the end of the last glacial cycle, some 10,000 years ago.

The Bishop's oo (pronounced ōō) is a member of the honeycreeper family (Meliphagidae), which numbers 170 species hailing from Australia and the South Pacific islands. Four species of oo have been known to science, each limited in range to a different Hawaiian island. Three of these, from Oahu, Molokai, and Hawaii, have not been reported since the beginning of this century and have thus been considered extinct. The Kauai oo had also been thought extinct but was rediscovered in 1960. Ornithologists now believe that fewer than ten individuals of this species remain. Prior to Mountainspring's discovery, no oo was known from Maui, although there had been scattered reports over the last century of oo-like birds of undetermined species. His sighting was therefore doubly significant: it not only resurrected one of the Hawaiian Islands' presumedly extinct species but also confirmed its previously hypothetical occurrence on Maui.

According to Mountainspring, "the fossil record and other historical evidence indicates that 70 percent of Hawaii's native land birds became extinct prior to the arrival of Western settlers." The causes of the Bishop oo's decline, however, are more related to nineteenth-century postsettlement influences. For example, in 1826, vengeful sailors dumped water infested with mosquito larvae into a water system, reportedly because the ruling chiefs denied them access to Hawaiian women. The nonnative mosquitoes became carriers of avian malaria and pox, with drastic results for native birds that had no resistance to these foreign diseases. Likewise, introduced predators, such as rats and cats, attacked birds unaccustomed to such mammals. Finally, indiscriminate grazing by cattle caused significant habitat destruction. Allowed to roam freely in the jungles, cattle fed on plants that did not have the thorns or other defenses present among continental flora.

But in the remote, high elevation of Haleakala, the oo may have found some sanctuary from human influences. Its very distance from habitation and its altitude had made Haleakala a special place, even to ancient Hawaiians. According to one Hawaiian myth, Haleakala,"the house of the sun," is the place where the ancient god Maui lassoed the sun by its "legs," or rays. The sun, fond of sleeping, had been racing across the sky to retire early for the night. But the short days that resulted left too little time for the Hawaiians' bark cloth to dry. One morning Maui caught the sun by its legs, just as it rose over the crater's rim. In return for its freedom, the sun agreed to walk more slowly across the sky.

Like the other Hawaiian Islands, Maui absorbs the sun's heat, creating an inversion layer of warm air at seven to nine thousand feet. Trade winds, heavy with moisture picked up while crossing a thousand miles of open ocean, rise as they cross Maui until they reach this inversion layer. Cooling as it gains altitude, the moistur condenses as rain. Haleakala is hig enough that little of the moisture passe over its 8,500-foot windward crest. Thus the brunt of the area's rainfall—some 25 inches per year—drenches Haleakala' windward slope at elevations between fiv and seven thousand feet, supporting a ver dant rain forest. On the lee side of this rim lies the dry expanse of the crater floor.

Mountainspring was working, as he stil does, for the U.S. Fish and Wildlife Ser vice on Hawaii when he began the excur sion that was to lead to the oo's discovery He flew to Maui early in May 1981, then hitchhiked to the leeward rim of Halea kala, which at 10,026 feet is the highes point on Maui. Here the road ended, and Mountainspring descended by foot into the crater, whose moonscape floor lay 3,000 feet below. It was on this same pow dery desert floor that the Apollo astro nauts trained for their missions.

Carrying a fifty-pound backpack Mountainspring began an eight-mile trek across Haleakala's cinder bottom, a dusty expanse crisscrossed by rugged lava flows. A line of red and black cinder cones roughly paralleled the route. At dusk, he set up camp to the sound of petrels calling as they returned to their nesting burrows.

The next morning, he wound his way through patches of Haleakala silversword, a rare plant endemic to the alpine deserts of Hawaii, and climbed up the 1,600- foot backside of the crater. Leaving the ridge trail behind, he dropped down the windward slope through an alpine grassland, stopping just at the upper limit of the rain forest to set up base camp.

From his camp, Mountainspring made daily trips into the rain forest. His remote study site had been unexplored by or-

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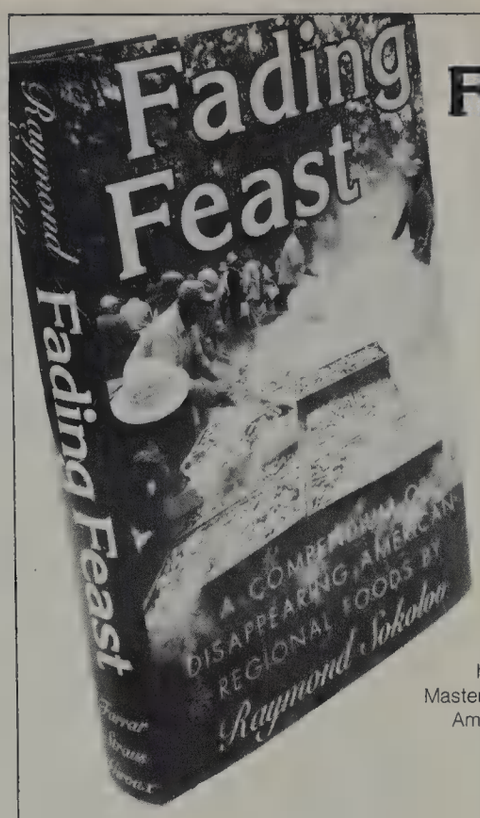

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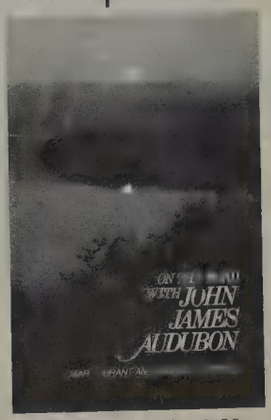

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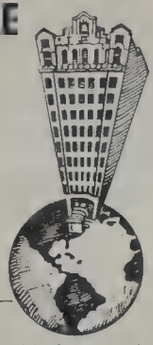

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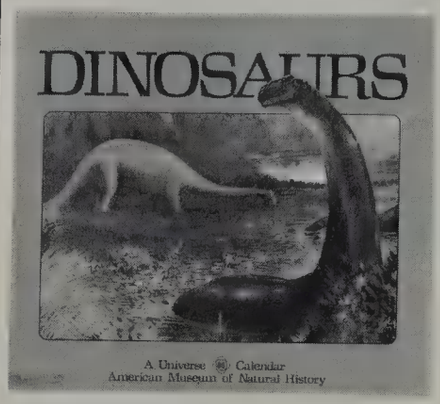

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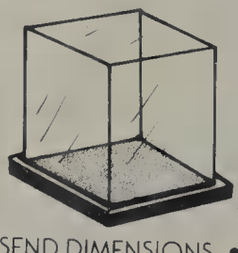

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nithologists until the late 1940s. It was this dense forest that the poo-uli, a hon creeper that feeds on mollusks, was fou in 1973. Here, too, this century's fi sighting of the Maui parrotbill was ma in 1950, followed in 1967 by the redisc ery of the Maui nukupuu, a honeycreep whose upper bill is twice as long as lower. These discoveries had given t area and its birds a certain elusive spark Spending days in this misty rain fore Mountainspring sighted many of the birds and others with exotic Hawaii names. The red pompon flowers of t dominant ohia tree (*Metrosideros*) co trasted brilliantly with the tree's twist dark gray branches and drab green liage. Thick moss and fern epiphyt jacketed the branches. Sheer gulches, c ated by eons of heavy rains, cut throu the luxuriant understory of small tr ferns and shrubs.

On May 10 at 10:00 A.M., Mou tainspring heard a series of long, accent "owh-owh" notes of low pitch and so rich tonal quality. From his readin about rare Hawaiian birds, he suspect that he had heard a supposedly extin species of oo. If this was an oo, he kne that it was reputed to be extremely shy. Mountainspring later recalled, "It w like a field test of all my years of exper ence to stalk the bird and find it."

He crept toward the songs through th dense understory and came to an overlo above a sheer gulch. He waited there f three hours, surveying the forest along th opposite gulch wall. Suddenly, a lon tailed black bird flew from the understo into the subcanopy. "I felt like a myste of the primeval Hawaiian forest was bein unveiled to me," Mountainspring said.

The moment he saw the bird, he starte to run through the identification proces honed by years of field experience. He be gan by looking at the bird's color an shape, immediately burning its essentia image into his mind so that he could rel cate it if it moved or have a minimal men tal record if it vanished in the dense vege tation. He recorded several field marks— the black tail, the yellow ear patch, and yellow tuft under the wing. He the looked for other specific field marks an behaviors. The process complete, he scrib bled notes and made sketches, recordin his observations in accordance with th stringent requirements of his profession

Only then did Mountainspring realiz that he was indeed seeing Bishop's oo, a species that had purportedly long since vanished into oblivion. Overcome by wha he later described as "a wave of bliss," Mountainspring was now able to drink up the scene more metaphorically.

Walter Rothschild's turn-of-the-century painting of the Bishop's oo

He felt, suddenly, a strong sense of ce, a sense, as he described it, "of really ng there . . . I fell into the scene before , retaining remarkably sharp and clear pressions of the vegetation and sky pat- n." For him, a curtain had been parted, ealing the image that Longfellow so y recorded in the first line of *Evange- e*: "This is the forest primeval."

Mountainspring broke camp a few days er to return to civilization. When he re- ned the trail that had led him to his iso- ed study site ten days earlier, his weath- d tracks were still the only ones printed in the mud.

It was perhaps fitting that Moun- nspring's trip was financed by an Amer- n Museum of Natural History grant m the Frank M. Chapman Memorial nd. As Mountainspring was bringing ck ornithological headlines from the aui rain forest, so, too, had Chapman ought back to the Museum many dis- veries from his fieldwork in the simi- ly remote jungles of South America.

On his return, Mountainspring examined specimens of the oo, studied historical records, and then published his report in *Elepaio*, the major ornithological journal of Hawaii. This, along with a letter to the chairman of the American Ornithologists' Union (AOU) Committee on Classification and Nomenclature, caused the committee to remove the mark indicating an extinct species from beside the Bishops oo entry in the *AOU Check-list*. The official arbiters of such matters had accepted Mountainspring's record, thereby resurrecting Bishop's oo.

Perhaps not coincidentally, at the age of eight, Mountainspring acquired his first bird book, an original, leather-bound edition of Chapman's *Handbook of Birds of Eastern North America*. It cost him fifty cents at a rummage sale and sparked his lifelong interest in ornithology.

Marc Breslav is a public relations consultant to natural history and environmental organizations

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Workshops for Young People

The Museum's Education Department is offering its *Workshops for Young People* again this fall, with such programs as: *Through the Eyes of a Child*, which introduces the Museum to five- and six-year-olds (accompanied by an adult); *Nature Activities for the Very Young*, for children in first and second grade; *Learning to Draw Animals*, for grades six, seven, and eight; *Origami*, for grades five and six; and *Discovering the Microscopic World*, an introduction to the microscope for children in grades six and seven. Fees for the workshops range from $10 to $30 (10 percent discount for members), and most begin in October and November. For more information, call (212) 873-7507.

Art of the Cameroon

In September and October the Education Department will offer a series of lectures to complement *Art of the Cameroon*, an ongoing exhibition. On September 22, Tamara Northern will deliver a slide lecture, "The Royal Art of the Cameroon Grassfields," in the Museum's Kaufmann Theater. Sylvia Boone will present "Masterpieces of Cameroon Art" on Sunday, October 6, in the Kaufmann Theater. Both take place at 2:00 P.M. and are free and open to the public.

Tiger, Tiger, Burning Bright

A photographic exhibition opens in Naturemax Gallery on October 1. *Tiger, Tiger, Burning Bright—An Indian Wildlife Portfolio* includes spectacular pictures of such Indian animals as the tiger, elephant, and thamin deer.

Faces Film Festival

Children ages six to fourteen are invited to a film festival sponsored by *Faces*, the Museum's new magazine, and the Membership Department. Three short anthropological films will show how children around the world live, work, and play. Among the subjects will be Eskimo children playing indoor games, the daughter of Polish immigrants in Canada, and a Navajo girl as she herds her sheep alone for the first time. A craft activity will also be included. Free copies of *Faces: The Magazine About People*, geared to eight- and fourteen-year-olds, will be given away to participants. *Faces* is published by Cobblestone Publishing in cooperation with the Museum. This free program for Museum members only will take place on

Peter Getzels, Harriet Gordon

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A scene from In the Footsteps of Taytacha

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The 1985 Margaret Mead Film Festival

The 1985 Margaret Mead Film Festival will feature forty-five films this year, twenty-six of which will be shown for the first time in New York. Covering a spectrum of anthropological subjects, the festival includes a documentary of daily life in a Chinese village and a Werner Herzog film on a mountain climber. Other highlights are:

A Man When He Is a Man, a humorous portrayal of male posturing in Costa Rica, also raises serious questions about male attitudes toward women.

The Memory of the Camps, a devastating documentary of German concentration camps during World War II, filmed during the Allied liberation.

Panare records the life of Amazon peoples as they strive to maintain their identity in a changing world.

Films will be screened Monday through Thurday, September 9–12, from 6:30 to 10:30 P.M. Tickets, available at the door each evening, cost $3.00 for members and $4.00 for nonmembers. For information and a complete schedule of the films call the Education Department at (212) 873-1070 on weekdays.

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The Earth's Crust Also Rises

An unmanned spacecraft has measured the upward motion of large porti of the earth, a consequence of the ending of the last Ice Age

by Stephen P. Maran

When last discussed in these pages, a NASA satellite named Lageos was slowly but seemingly inexorably losing altitude (see "Fall from Space," *Natural History,* December 1982). From that unexpected circumstance, it was deduced that a weak electrical force was tugging at Lageos, making it descend. The slow fall could bring the 905-pound craft crashing down on the earth 500,000 years from now, instead of in the millions of years originally expected. However, since our previous report, the rate of descent has varied and the satellite may even be rising at times. Of still greater interest to geophysicists is another, more subtle change in the satellite's orbit. This effect, called nodal acceleration, seems to be due in part to slow changes in the earth's gravity, which are caused by the upward motion of the land in Canada, Finland, Scandinavia, and other regions that were covered by huge ice sheets during the last Ice Age.

If I could carry a tune, I would be humming Rodgers and Hammerstein's "My Favorite Things" at this point in the story. That's because Lageos—short for Laser Geodynamic Satellite—is my favorite spacecraft. Unlike nearly all other satellites and probes, it does not require hundreds or thousands of radio-transmitted commands every week to keep it functioning. In fact, it is no bother at all. No command that NASA controllers can issue would have any effect on Lageos's faithful completion of its appointed rounds; the satellite has no onboard radio receiver to accept commands and no computer or other equipment to execute them. Unlike such manned spacecraft as the space shuttle, Lageos follows no mission rules but operates instead under the laws of nature. The challenge it presents to the scientist is to infer the finest details of some of the laws from the changes in Lageos's or that occur over time.

To determine the changes in Lageo orbit, the craft is tracked from the grou by laser. The lasers can home in on the s ellite because its two-foot-diameter out skin is studded with 426 retroreflecto optical devices that have no moving pa but that flip incoming light beams direct back at their senders. Thanks to the desi of the satellite, the careful choice of the bit in which it was initially placed, and t laser tracking, Lageos's present, slow changing orbit has been determined wi higher precision than that of any previo satellite. Therefore, as Lageos orbits t earth, it functions as a roving referen point, so that measurements of its pa over tracking stations at various locatio can be used not only to find changes in t satellite's motion but also to ascerta changes in the positions of the statio themselves. Laser tracking stations are s up on different continents, thereby e abling investigators to follow the con nents as they drift with respect to one a other at almost unimaginably slow rate Tracking stations are also located on bo sides of the San Andreas fault zone California, making it possible to monit the slippage of the land along the zone.

Among the geophysical phenomena r vealed in precise detail through the trac ing of Lageos was a tiny, measurable, ten porary increase in the length of the da apparently related to an especially stron occurrence of the Pacific Ocean's El Ni disturbance in 1982–83. This discover was confirmed by independent measur ments made with radio telescopes tha used quasars as fixed reference points fo determining the earth's rate of rotatio

ner findings from the laser tracking a include measurements of slight anges of a few inches in the positions of north and south poles of rotation, ich are several yards from the geo-aphic poles.

Scientists initially assumed that La-os's orbit was so stable that the craft uld continue revolving around the earth millions of years. Then, should all life destroyed, either by human or natural astrophe, Lageos, surviving high above ground, might constitute important dence of the advanced state of civiliza-n that we had once attained. By captur-; and examining the orbiting satellite, raterrestrial visitors to the solar system uld learn something of the vanished in-bitants of our planet.

To assist in this educational process, geos carries within its protective alumi-m shell an informative plaque with a ssage for potential finders. Designed Carl Sagan of Cornell University, the aque features graphic depictions of the proximate positions of the continents at ee widely separated points in time, in-ading the May 1976 date on which geos was launched into space. By de-ding the data encrypted on the plaque d comparing the disposition of the con-ents at the time of the hypothetical visit th the maps on the plaque, the time apsed since the satellite was launched uld be inferred.

Knowing all of the above, I learned with reboding in 1982 that Lageos was unex-ctedly falling at the rate of 1/25 of an ch per day, ten times faster than antici-ted. Even Lageos, it appeared, is not rmanent. But there was an interesting delight to the bad news. David Rubin-m, a geophysicist colleague of mine at

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Goddard Space Flight Center, concluded that Lageos's fall was due to the buildup of an electric charge similar to the static electric charge that builds up in your body when you walk across a rug. Once so charged, the satellite is susceptible to an electric force, called plasma drag, that is exerted by electrified gas in its orbital surroundings. That seems to be the cause of Lageos's fall, and that is where we left the reader in December 1982.

Since 1982, Rubincam and others have found that the rate at which Lageos descends is varying. Sometimes the descent rate approaches zero, meaning that the satellite's slow fall almost stops. One study suggested that Lageos had begun to rise. However, it now seems to be falling. These unexpected variations in the satellite's descent may be due to changes in a pressure force exerted on it by sunlight reflected from the earth. Such light is called earth albedo. We have known for more than two decades that earth albedo can disturb the motion of satellites, and these well-understood effects were taken into account before the Lageos investigators concluded that an additional process was affecting the motion of the satellite. What's new is that the gradual changes in Lageos's orbit have been determined with such precision that investigators have detected among them the apparent consequences of variations in the amount of sunlight that is reflected in the Northern and Southern hemispheres.

At least, that's the conclusion to which four Italian physicists at three institutions in Pisa are leaning. According to the Italian scientists, the differences in the earth albedo emanating from the two hemispheres (which, in turn, depend on the season of the year) can account for the unexpected variations in Lageos's rate of fall. Another investigator suggests that additional changes in the earth albedo, which correspond to different times of day, contribute to these variations. This inv gator specifically proposed that syst atic differences in the amount of earth bedo shining on Lageos as the sate moves through dawn and dusk on its o are what change the rate of fall. This cess may even rival plasma drag in br ing the satellite down.

Geophysicists have been studying other phenomenon derived from l tracking of Lageos. Lageos's orbit in sects the plane of the earth's equato two points, called nodes. The position the nodes move, and when the rate nodal motion changes, the phenomeno referred to as nodal acceleration.

Nodal acceleration in the orbit of a ellite can be caused by such forces ocean tides. However, when all previou identified causes were subtracted fr the observed nodal acceleration of geos's orbit in two recent independ studies, a small but certain measu acceleration remained. The studies w prepared by Rubincam and by a team by Charles F. Yoder, an astronomer at Jet Propulsion Laboratory in Pasade California. Although the studies agree the meaning of the nodal accelerat they disagree on its magnitude. Yoder group, which published first, fou an acceleration about twice as great that later calculated by Rubincam. But the investigators agree that the accele tion results from postglacial rebound the slow rise of landmasses in the Ca dian Shield, Scandinavia, Finland, a elsewhere that were depressed by weight of overlying ice sheets during last Ice Age, which ended perhaps as cently as 5,000 years ago.

The observation of postglacial rebou is not a surprise: geologists have kno about it for decades; the Swedish bish of Abo noticed it in 1616; and aborigi

Along the San Andreas fault, land slippage is tracked by lasers. R.N. Mariscal; Bruce Coleman

ups recognized the rise in the land long
Scientists began to understand the
se of this rise after several pioneering
lies in the nineteenth century. One of
e geologic surveys concerned the coast
Maine and was published in 1874 in the
noirs of the Boston Society for Natu-
History. The Maine surveyor, N.S.
ler, approached his coastal study skep-
lly, since he suspected that many pre-
is reports of the rising level of the rocks
originated with sailors and ships' offi-
in need of natural explanations for
wrecks for which they might other-
e be held accountable. Shaler consid-
d that a sailor who ran his ship aground
the coast of Maine "was naturally in-
ed to foster the opinion that the rocks
e growing nearer the surface year by
r." Nevertheless, from his study of an-
nt seashells found far above the con-
porary sea level and other geologic evi-
ce, Shaler confirmed that the sea level
changed in a way consistent with a
in the land, and he made an important
tribution by pointing out that this ef-
is pronounced in regions once covered
glacial ice sheets. Similar work by a
ish contemporary of Shaler showed
same correlation between a rise in the
d and the previous burial of that land
er a glacial ice sheet in the British Isles
elsewhere.

Since Shaler's time, geologists studying
tglacial rebound have determined the
rage rate at which the land has risen
e the last Ice Age. The nodal accelera-
in Lageos's orbit now enables geo-
sicists to measure the current rising of
land, thus confirming that the process
till under way. Furthermore, because
nodal acceleration depends on the re-
ribution of mass within the interior of
earth and not simply on the level of the
d surface, the measured acceleration
vides basic new information on the vis-
ity of the earth's mantle, the layer just
eath the earth's crust. Although the
ntle consists of rock, the great pressure
temperature at depths of many miles
ke it resemble an extremely sluggish
ving fluid.

Geophysicists still hope that one day
p-drilling experiments will penetrate
earth's crust and directly sample the
k of the mantle below. Until then, the
er tracking of Lageos will continue to
vide a sophisticated way to explore our
net's inner as well as outer space.

*phen P. Maran is a senior staff scien-
in the Laboratory for Astronomy and
ar Physics at NASA's Goddard Space
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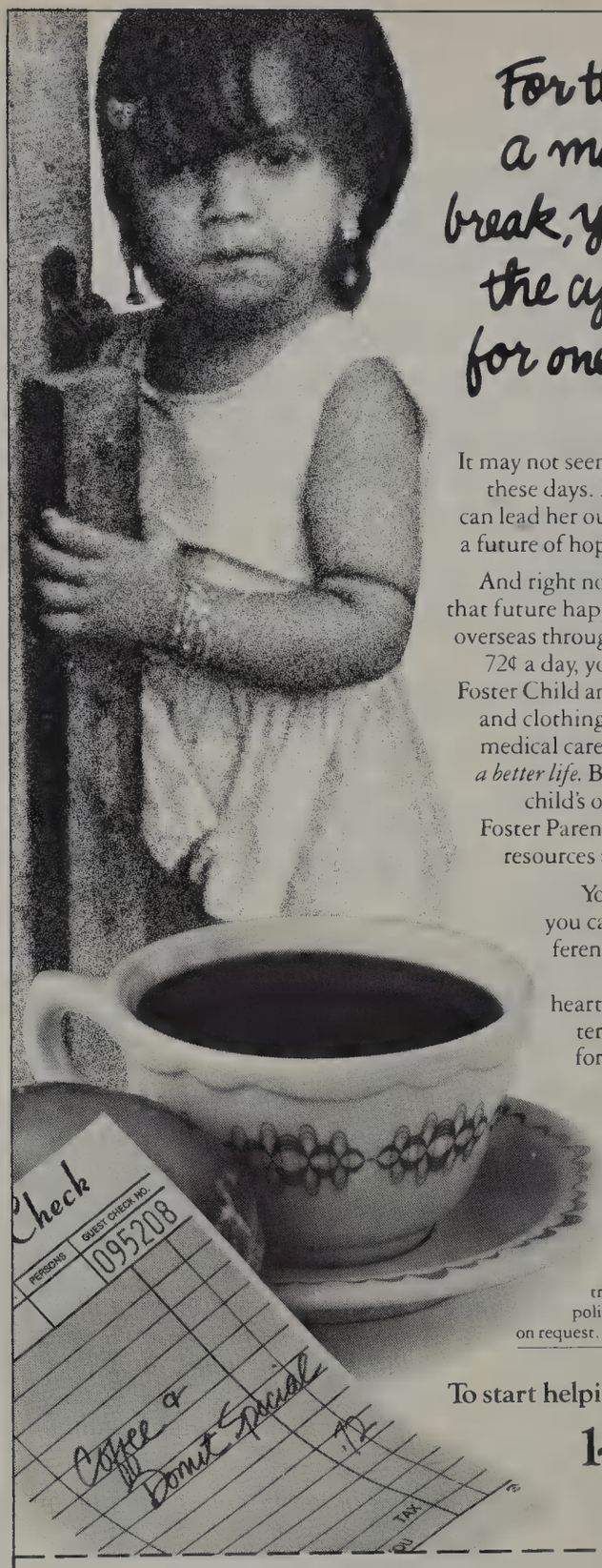

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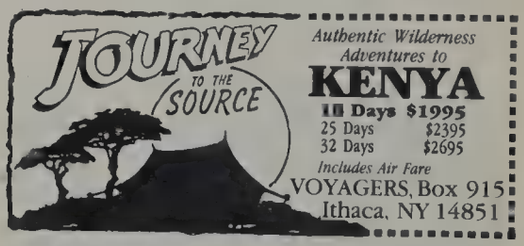

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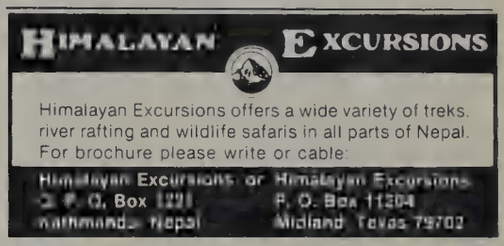
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Lovely Mornings

Thomas D. Nicholson

Mars recovers quickly from the obscu- of its conjunction with the sun in Au- and climbs rapidly into the morning it can be seen before sunup by mid- nth. Mars joins Venus and the bright Regulus (in Leo) to make an interest- threesome in the dawn sky. Venus is obvious leader in brilliance; Mars is laggard and the easternmost (lowest) ne three. Mercury can also be found in morning twilight, low in the eastern during the early part of September. umn morning configurations of the net are always the best.

The planetary scene is clearly shifting y from the evening sky in September, he morning improves. If not for Jupi- the evening would be rather poor. Ju- r's only competition comes from Sat- , not particularly distinguished in earance, which is to the south of our and sets soon after darkness. Jupiter is ething else again. At about dark it be- to appear near the south and remains he sky until well after midnight. The on may help in finding Saturn on the n; thereafter it will be obscured by the izon haze.

The following events are given in local e unless otherwise noted.

September 1: The moon is already two a half days past full, yet moonrise is about an hour after sunset. It's the rvest moon" effect displaced a bit. onlight lasts virtually from dark until n tonight. When the moon climbs ner, you will find it near the border of ces and Cetus.

September 2–3: Still waning, the moon ves through Pisces into Aries.

September 4: Mercury almost covers rs while passing below it tonight, com- within a half minute of arc, about the of a dime seen at a distance of 400 . Unfortunately, the two planets are up in daylight and are located where we 't see them. The moon is at apogee, far- st from the earth.

September 5: The moon is near the Ple- es when it comes up tonight after 9:00 . The closely gathered stars of this clus- (sometimes called the Seven Sisters) just above the moon and to its right.

September 6–7: The waning moon passes above the Hyades, a V-shaped star cluster in Taurus, the Bull. The bright red star in the V is Aldebaran. Last-quarter moon is at 7:16 A.M. on the 7th.

September 10: The morning moon is in Gemini, nearly in line with and below the constellation's twin stars, Pollux and Castor. Much brighter Venus is below the moon to its left.

September 12: Venus and the old moon are always a pretty sight, and you should see them this morning about dawn. We won't see the moon again until it passes the sun and emerges to its left as an evening crescent.

September 14: New moon, at 2:20 P.M., EST, is moving across the border between Leo and Virgo, along with the sun.

September 16: Now two days past new, the young crescent moon can be glimpsed in Virgo tonight, just above the bright star Spica, if the southwestern sky is clear. Perigee moon, nearest the earth, was earlier today.

September 18: Saturn rides the sky with the crescent moon tonight, although the moon is drifting slowly to the left and beneath it in Libra.

September 19: The moon has left Libra behind, along with Saturn. The lunar companion tonight is Antares, in Scorpius, although the moon is slipping to the left into Ophiuchus.

September 21: Regulus is very near Venus this morning; the planet passes a moon's diameter (0.5°) away at noon. The moon, at first quarter at 6:03 A.M., is in Sagittarius.

September 22: The sun crosses the equator in Virgo today, on the way south of it, at 9:08 P.M., EST, and autumn begins in the Northern Hemisphere. Most years autumn starts on September 23, but the "breaks of the game" we play with leap year cause the time to vary. Autumn begins on the 23d in Asia, Africa, Australia, and Europe, but the changing date doesn't catch up to us until later.

September 23: Jupiter is moving slowly to the west (right) through Capricornus (it's retrograding), while the moon is moving to the left just to the planet's south. The effect is obvious at 1:00 A.M. (on the

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24th), as the moon drifts toward Jupiter, past it, and then away.

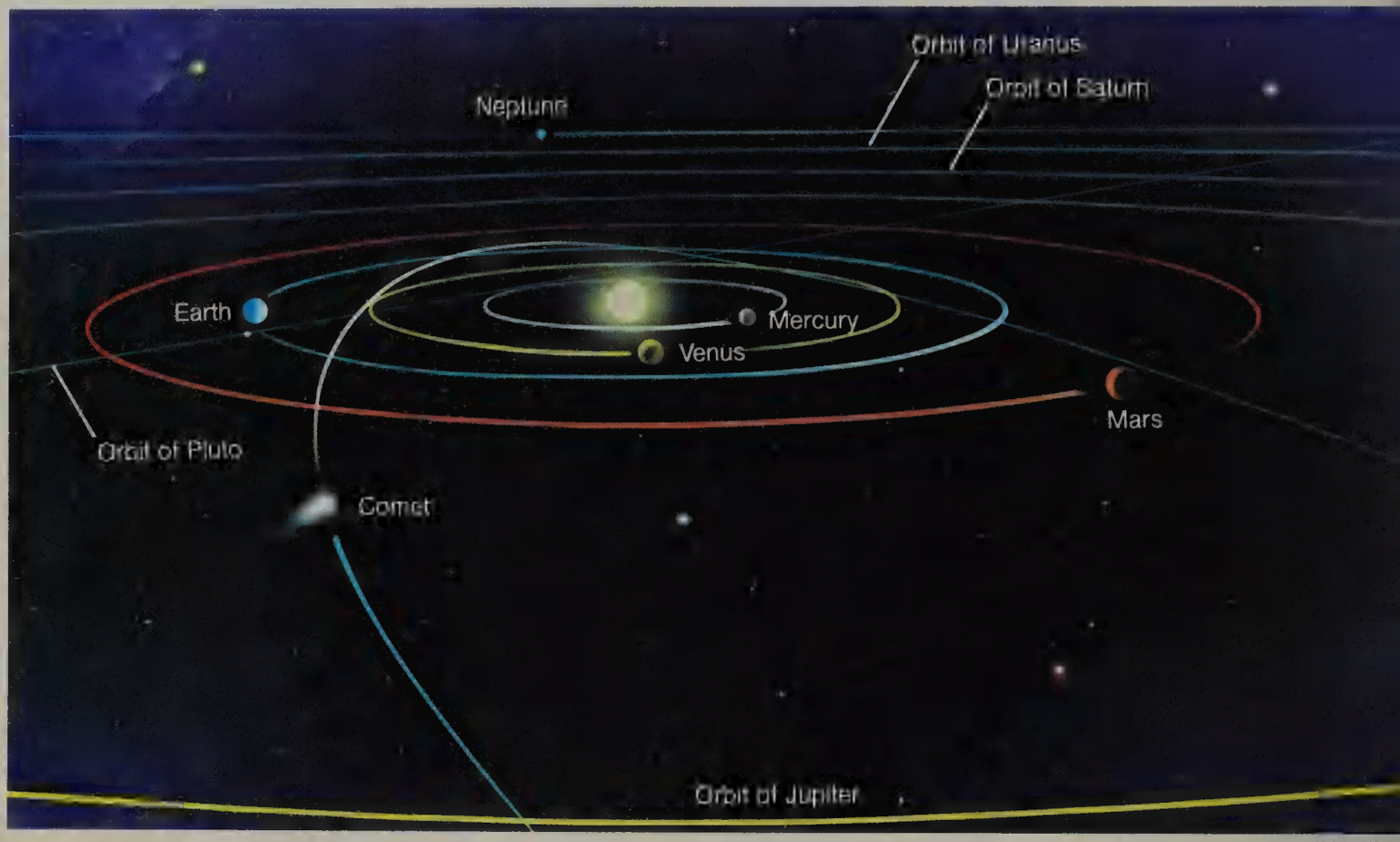
September 24–27: The gibbous moon widens nightly as it slips through Capricornus, Aquarius, and Pisces on the route toward the vernal equinox.

September 27: The equinox (which implies that day and night are of equal length) took place some days ago, but it is today that the interval between sunrise and sunset is exactly twelve hours. Of course, if you include twilight, the sky is light for more than twelve hours.

September 28–29: The full moon of the 28th, at 2:08 P.M., EST, is the harvest moon because it is so close to the vernal equinox. Moonrise occurs so near to sunset for the next several days that it appears as if we have a full moon right to the end of the month.

Editor's Note: The Sky Map in the July issue shows the evening constellations and stars this month and gives times for use

Halley's Comeback



Helmut Wimm

As Halley's comet circles the sun on a 7.2-billion-mile journey every seventy-six years, it traces a series of lazy loops in the earth's sky. Each spiraling loop takes about a year to complete, reflecting the earth's motion around the sun more than that of the comet. During the long series of seventy-five or so spirals, the loops drift slowly westward until suddenly the comet approaches the inner solar system and bursts across more than three-fourths of the sky in less than a year.

The westward dash begins this year on September 22. On that date, Comet Halley completes its final easterly (retrograde) jog in Gemini and swings westerly out of its last spiral, starting its spectacular eight-month sprint. From now until May 1986, the comet builds its coma and tail, swings around the sun, and loses them again, while twice coming close to the earth. On May 31, 1986, the comet turns easterly once more, beginning another long series of spirals that will not end until its next appearance in the year 2061.

This month the comet is still well beyond the distance to Mars; at midmonth it is 237 million miles from the sun and the same distance from the earth. It will be closer to the earth than to the sun from now until the year's end, months during which the earth and the comet close in toward one another.

Within the next month, Halley's comet will increase in brightness by more than five times, given the rapid pace at which the earth and the comet approach each other. By the end of the first week of November, Halley should be within range for binocular viewing, and from then until early January, Northern Hemisphere viewers will have their best shot at it.

History provides us with vivid accounts of Comet Halley's appearance, whetting our appetites for this one chance in a lifetime (for most of us) to see it. Unfortunately, history hasn't been completely honest with us. Although it records every appearance but one since 240 B.C., twenty-eight in all (with glowing accounts of some), the tradition of the spectacular comet we have inherited doesn't reflect the varying conditions that govern its visibility from the earth. Consequently, there remains some uncertainty over the comet's appearance this year. Historical evidence and the circumstances of its former journeys past the earth suggest that it will not be very bright or well placed for viewing in our sky. But despite the accuracy with which we can foretell their movements, comets are unpredictable at best. Data thus far indicate that Halley's comet may be brighter than predicted, although not greatly so.

But however poor the forecasts may be and whatever may happen, don't give up hope. Most likely, with enough effort, everyone who really wants to see this captivating object will be able to. Now is the time to prepare by dusting off your binoculars, getting out your star maps, and trying your hand at finding your way in the sky. In another month you can begin your own personal search for the most famous comet of history.

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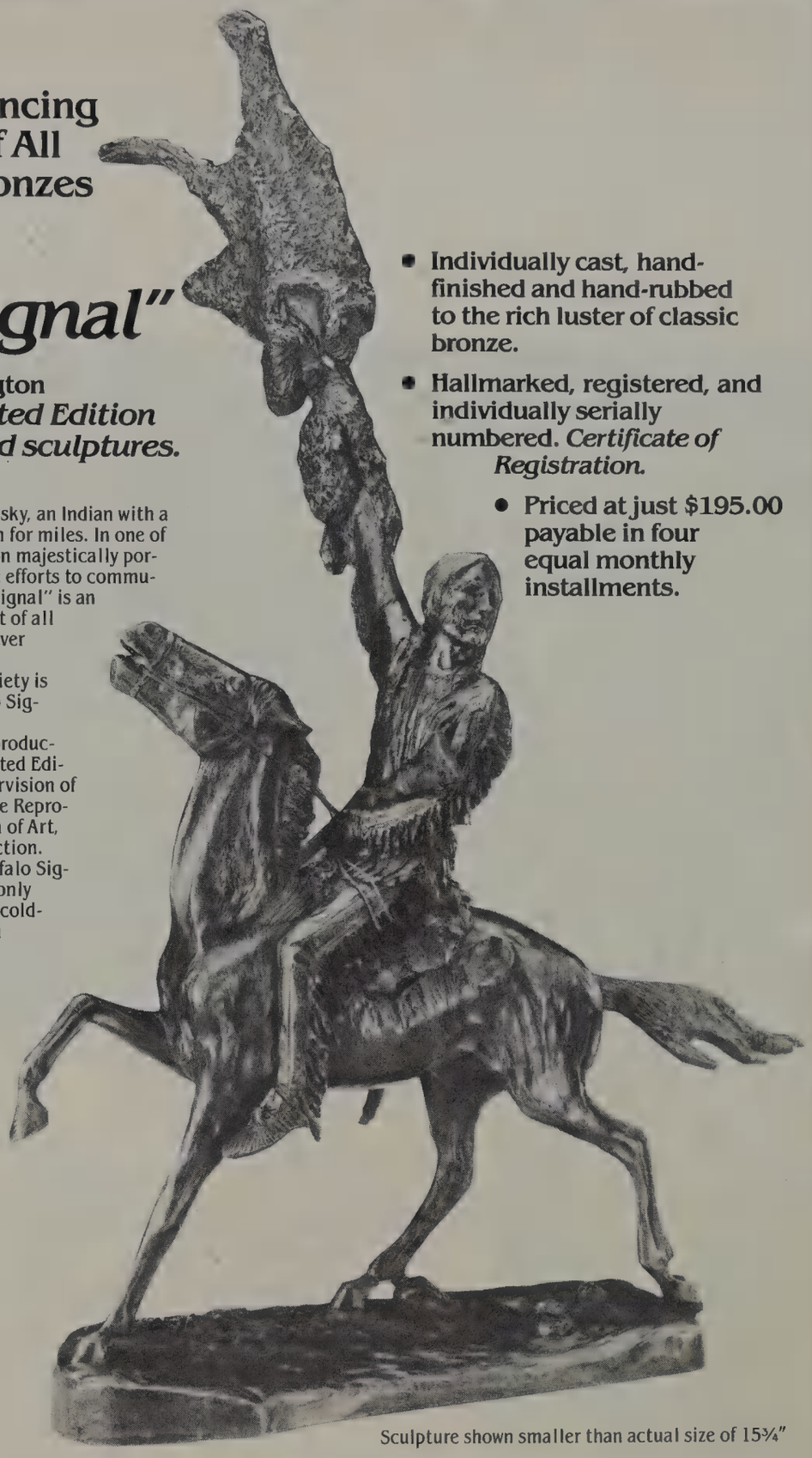

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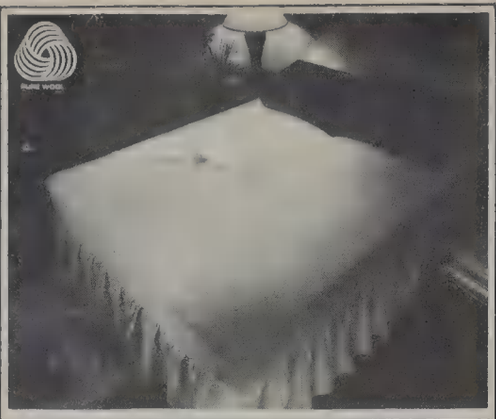
The Beetle With a Boring Head

Ray Mendez spotted this brentid beetle while cruising around one of his favorite Trinidadian locales—the backyard of the Asa Wright Nature Centre. The beetle had come into some flowers growing near the center's bamboo patch and then climbed up on one, possibly to chew some pollen. Mendez marveled at the engineering job that was its head. The whole front portion of the animal was head—a long stalk that narrowed, threw off a couple of antennae, and ended in two tiny jaws. It swiveled smoothly, as if moving on a ball bearing. Mendez could see it swiveling, too, for the animal, while very slow and mechanical and regular, never actually stopped moving.

According to Walter Linsenmaier, a German zoologist, brentid beetles (sometimes called giraffe beetles) often have long heads and faces that project forward, like the trunk of an elephant, "to grotesque lengths." The brentids use them to bore into plants or fruits they eat, but even more often, they use them to drill into wood or bark so they can lay their eggs. According to Linsenmaier, the larvae then gnaw out shafts of their own and eat the fungi that pop up in them.

Mendez has observed this himself in Trinidad. He has often seen a congregation of beetles on a recently fallen tree. The sappy area in the cut of the tree seems to attract beetles, flies, and even moths and butterflies. At other times he has seen brentids nesting in the hollow stems of bamboo. In any case, this particular beetle never really stopped fidgeting, but somehow Mendez managed to get a couple of shots of it. Enlarged here, the bug looks a lot more fearsome than it does at the Asa Wright Nature Centre—where brentids rarely get to be more than a couple of inches long.

Photograph by Raymond A. Mendez



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Additional Readin

Dickson Mounds (p. 12)

Paleopathology and the Origins of Agriculture, edited by Mark N. Cohen and George J. Armelagos (New York: Academic Press, 1984), compares the health of prehistoric farmers with their hunter-gatherer forebears. A chapter by Alan H. Goodman et al., "Health Changes at Dickson Mounds, Illinois (A.D. 950–1300)," chronicles the effects of economic and cultural change on the health of prehistoric populations in this area. Robert Gilbert, Jr., and James Mielke edited *Analysis of Prehistoric Diets* (New York: Academic Press, 1985), a report on the methods used to interpret prehistoric nutritional stress. For a review of mankind's first three million years, see Robert J. Wenke's *Patterns in Prehistory* (New York: Oxford University Press, 1980).

Mongooses and Hornbills (p. 36)

In *King Solomon's Ring* (New York: Thomas Y. Crowell, 1952), Konrad Z. Lorenz speculates, among other things, that our own instinctive behavior has much in common with that of animals. Niko Tinbergen, the Dutch-born zoologist based at Oxford, introduces ethology as objective science in *The Study of Instinct* (Oxford: Clarendon Press, 1951). O. Anne Rasa's book *Mongoose Watch: A Family Observed* is scheduled to be published by Doubleday and Co., New York, in January 1986.

Butcher's Pioneers (p. 44)

Solomon D. Butcher's pictures constitute the most comprehensive photographic record of the pioneers who settled the Nebraska plains. Combining critical analysis with biography, John E. Carter's *Photographing the American Dream,* to be published by the University of Nebraska Press, Lincoln, in October, establishes Butcher's place in photography. Solomon D. Butcher's *Pioneer History of Custer County, Nebraska* (Broken Bow, NE: Purcell, Inc., 1976), a reprint of his 1901 photographic history of the area, is available from Harry Purcell, 1210 Holly Livermore, CA 94550 (hardcover, $15.50; paperback, $9, postage extra). Roger L. Welsch's *Sod Walls,* an analysis of sod house architecture as a form of folk art, was published by Purcell in 1980 ($10, paperback). Welsch derived much of his information from Butcher's photographs, as well as from people whose families lived in sod houses. Robert Ta *Photography and the American Scene* history of photography from 1839 to 18 was originally published in 1938 and printed by Dover Books in 1964. One the better articles written about Butche David Vestal's "S.D. Butcher of N braska" (*U.S. Camera Annual,* U Camera Publishing Corp., New Yo 1971).

Peripatuses (p. 54)

Michael Ghiselin's *The Economy Nature and the Evolution of Sex* (Ber ley: University of California Press, 19 is a refreshingly learned book that, cording to its author, "is a cross betwe the *Kama Sutra* and *The Wealth of N tions:* it seeks to explain the diversity of productive phenomena in the light some ideas derived from classical econo ics." *Living Fossils,* edited by Ni Eldredge and Steven M. Stanley (N York: Springer-Verlag, 1984), include short chapter by Ghiselin on the peri tus, reviewing the animal's taxonor ecology, and other aspects. Females larger than males in a majority of anir species, including the peripatus, for number of reasons; Stephen Jay Gou looks at these in "The Oddball Hum Male" (*Natural History,* July 1982, 14–22). Gould's "Sex and Size" (*Natu History*, August 1983, pp. 24–27) exa ines a general phenomenon in nature—s change—and ponders why the pattern changing from male to female, rather th from female to male, is more common.

Ants and Treehoppers (p. 62)

Catherine M. Bristow's "Treehopp Transfer Parental Care to Ants: A N Benefit of Mutualism" (*Science,* vol. 2 pp. 532–33) is one of the few articles these insects that isn't extremely techni or mainly concerned with their system ics. A new edition of A.F.G. Dixo *Aphid Ecology* (London: Blackie/N thuen, 1985) includes a readable review the phloem-feeding insects, closely rela to treehoppers. E.O. Wilson's *The Ins Societies* (Cambridge: Harvard Univ sity Press, 1971) treats ant–aphid inter tions, and John N. Thompson's *Inter tion and Coevolution* (New York: Jo Wiley and Sons, 1982) is one of the f books that deals with mutualisms and h they evolved.

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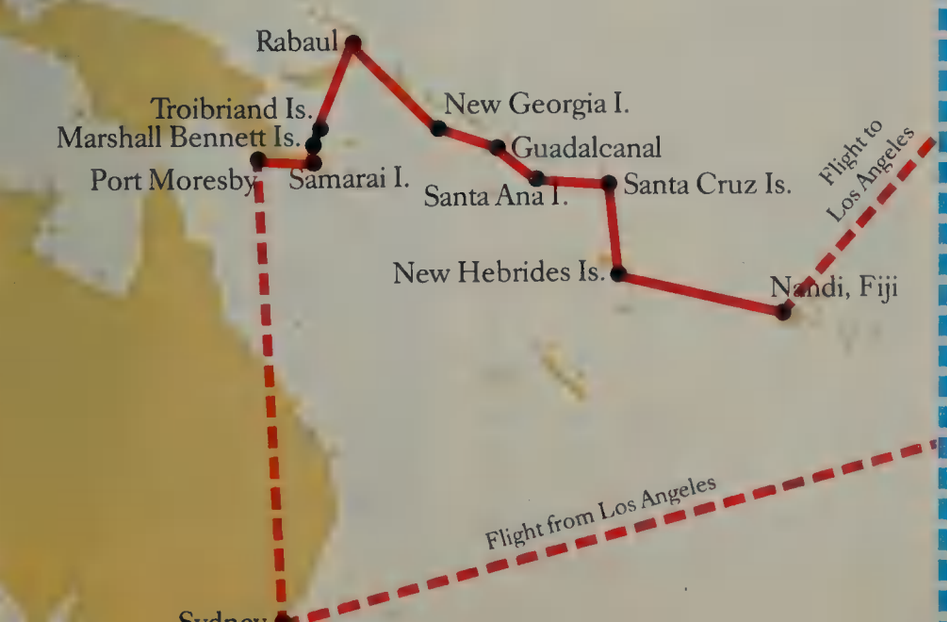

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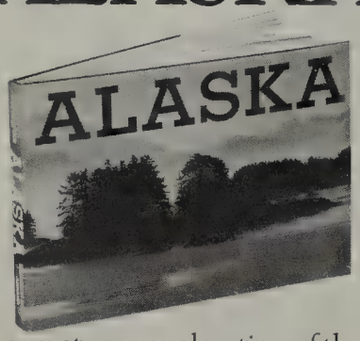

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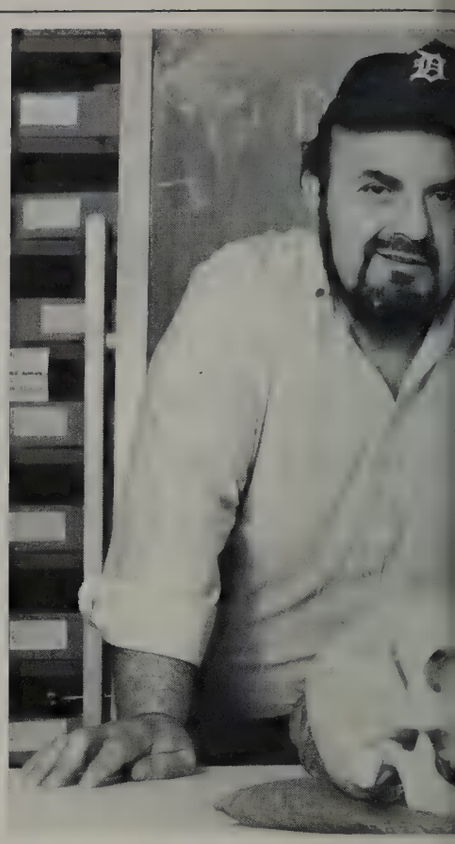

Alan H. Goodman (page 12), a Bost Red Sox fan, and **George J. Armelag** a Detroit Tigers fan, put aside their d ferences long enough to study the ske tons of prehistoric Native America buried at Dickson Mounds, Illino Their aim has been to see how the adve of agriculture affected the health these early people. Goodman was o of a number of graduate students w worked on this research under the gui ance of Armelagos, a professor of a thropology at the University of Mass

ts at Amherst. Armelagos is now
ng diet and disease among pre-
c Nubians in the Sudan. Good-
s a visiting assistant professor of
cal anthropology at Hampshire
e, in Amherst, and a postdoctoral
at the University of Connecticut
l of Dental Medicine and Depart-
of Nutritional Sciences. His
t work includes using dental de-
as indicators of fetal, infant, and
ood physiological stress in con-
rary groups in rural Mexico.

John E. Carter (page 44) has a passion for the Great Plains (generally) and the state of Nebraska (specifically). "Almost all my time is spent studying and interpreting Nebraska culture. I am one of those fortunate few," he says, "who manages to get paid for his avocation, hobby, and diversion." As curator of photographs for the Nebraska State Historical Society, Carter has access to the Solomon D. Butcher Collection of glass plate negatives—the pride of the Society's photographic holdings. "I was struck by the fact that no serious analysis of Butcher's life or work had been done," he observed. "The book from which this article is excerpted represents five years of research on my part and is a serious attempt to locate Butcher in the history of the American West as well as in the history of photography."

R. Bruhn

O. Anne Rasa (page 36) has been studying the behavior, sociology, and ecology of Africa's dwarf mongooses for fifteen years; the unusual and unexpected mutualism between the mongooses and some hornbills first caught her attention in 1980. A Heisenberg Scholar at the University of Bayreuth in West Germany, she spends four months of every year in the Taru Desert of Kenya. Next year, Doubleday will publish the results of her mongoose studies in *Mongoose Watch: A Family Observed*. Rasa describes herself as a "naturalist interested in all aspects of plant and animal ecology in Europe and Africa, especially those relevant to conservation." She is particularly concerned about the fate of "birds and small mammals, which are overlooked in most conservation projects." Rasa does not restrict herself to smaller animals, however; she also breeds and shows Welsh cob horses.

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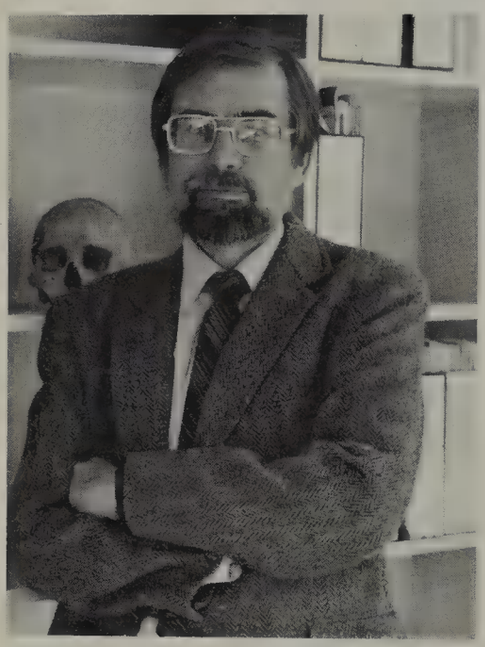
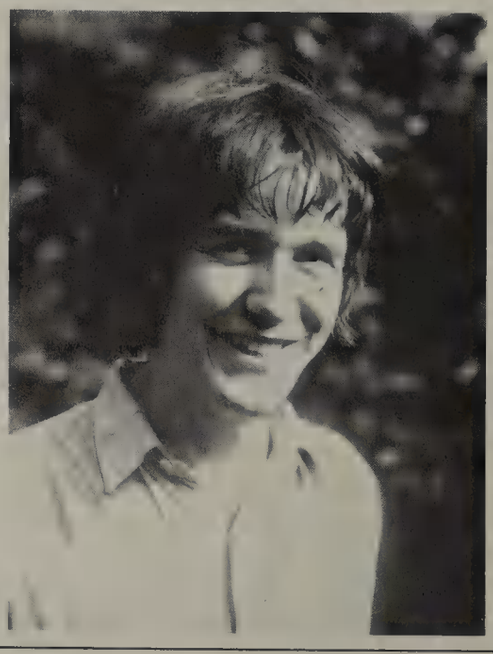
While doing research for his book *The Economy of Nature and the Evolution of Sex*, **Michael Ghiselin** (page 54) unearthed information on modes of reproduction in various animals, among them the living fossil *Peripatus*. Ghiselin's career has taken him to the academic realms of Stanford, Harvard, and Berkeley (among other schools) and into the field in the Malay Archipelago, Palau, the Caribbean, and Mexico. His *Triumph of the Darwinian Method* is perhaps the most widely known of his works. Future projects include further investigation of the mechanisms of natural selection, in particular the evolution and classification of sea slugs. An invertebrate specialist, Ghiselin was awarded a MacArthur Prize Fellowship in 1981 and is now a research fellow at the California Academy of Sciences in San Francisco.



Treehoppers, the sugar cows of the insect world, which are protected and "milked" by ants, have interested **Catherine M. Bristow** (page 62) since she was a graduate student at Princeton. Her initial interest was in the predators of treehoppers and aphids, which also excrete sugar. But you can't watch these bugs' predators without also noticing the ants, since the ants violently attack anything that remotely threatens the flow of sugar. So after a while, Bristow forgot entirely about the predators and focused instead on the mutualistic relationship between ants and sugar producers. As she points out in her article, treehoppers are not as passive as they might seem—they have evolved ways to exploit the ants' sweet tooth. Bristow's newest interest, however, is the setting for this phenomenon—the host plant. She speculates that it may have an important role in mutualism. "If ants are so beneficial, why are so few aphids tended?" she asks. "What effect does the plant species have on an aphid's ability to attract ants?" Bristow is currently based at the University of California, Davis.

To catch a peripatus in action, pho
rapher **Raymond A. Mendez** (page
knew he had to create an ambiance:
lighting, a gentle tropical breeze,
food, a moist, mossy clay bank. By c
ing a peripatus at the Asa Wright
ture Centre in Trinidad with a ho
made habitat, the right ventilat
crickets, and light no greater than tha
a full moon, Mendez shot a series on
nocturnal hunter at work. But sensi
as he is to the ways of wild peripatu
Mendez attributes his chance to ph
graph a peripatus giving live birth to
ilance and a lot of luck. His former w
in research and exhibits at the Ameri
Museum of Natural History and his
rent nature photography have allo
Mendez to combine three loves: art,
mal behavior, and entomology. Wil
photography, he stresses, should
"more than portraiture"; his goal is
perfect behavioral shot." Mendez us
105-mm macro lens with extension tu
and strobes and, for extreme closeup
Nikon-adapted Zeiss Luminar 25-
1.35 microscope lens. His work can
be seen on pages 62 and 98 of this is

Zoologist **Morley Read**'s first meeting with a peripatus (page 56) was a case of pure serendipity. He encountered the animal in Trinidad in 1978, while searching a rotting log for reptiles. Since then, he's gotten to know the "walking worm" quite well and is completing his doctoral project on peripatus feeding behavior. Read is a research student at the University College of North Wales, but his work has taken him to Brazil, the Lesser Antilles, and Tobago, as well as Trinidad. When not stalking peripatuses on tropical stream banks, Read captures natural history subjects on sound recordings and film. His footage has been broadcast on such popular BBC television series as "Life on Earth" and "The Living Planet."



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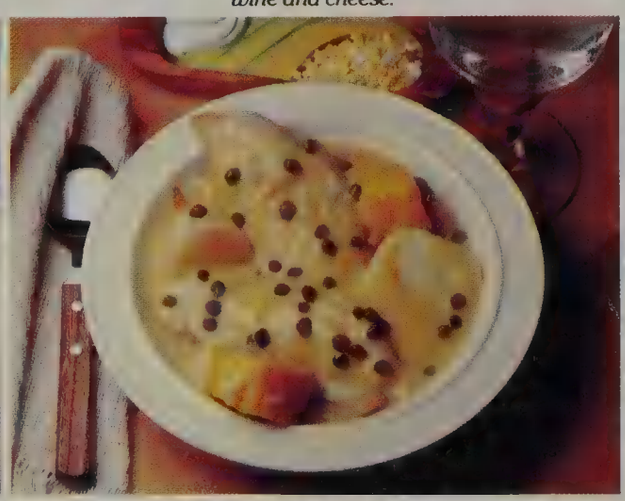

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NATURAL HISTORY

Vol. 94, No. 10, October 1985

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Thomas D. Nicholson, Director
L. Thomas Kelly, Assistant Director

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Letters

Lazy Beds and Washerboard Ridges

"One Potato, Two Potato," by John Omohundro (June 1985), documents well the ecological soundness of "lazy bed" cultivation in Newfoundland. Lazy beds are an efficient system for potato gardening, providing drainage, warmth, and high yields per acre in marginal environments. Such benefits are not restricted to Newfoundland but are found throughout the Celtic fringe of Europe (Ireland, Scotland, and elsewhere) even today.

Lazy beds were an integral part of Ireland and Scotland's combined tillage and grazing economy, which became increasingly dependent on potatoes after 1700. In this mixed agrarian context, lazy beds provided another, subtle benefit to rapidly expanding rural populations. When farmers allowed lazy bed plots to go back into grassland, the beds crumbled and eroded into soft, washerboard-like ridges. These ridges effectively increased the surface area of grassland where the lazy beds had been. In any particular plot, the surface area increased by 5 to 15 percent, depending on the erosion pattern. Thus, more grass was produced by the plot of land.

In nineteenth-century Ireland, the surface area expansion caused by old lazy beds was not restricted to small plots; in some cases, entire village hinterlands were transformed. Many of these areas may still be seen today. An extreme example of "washerboard" land is on the slopes of Killary Harbor, a deep valley in County Mayo. The ridges are fossil testimony to the struggles of farmers who survived the famine and postfamine decades.

Eric Almquist
Belmont, Massachusetts

Who's Stung?

In "Anatomy of a Sting" (July 1985), Jim Robbins understates the importance of the Peregrine Fund to survival of the peregrine as much as he overstates the importance of illegal taking in saying that the Fund has "already raised several hundred birds and released them into the wild." The actual number at the end of 1984 was about 1,400, and several hundred more have been released in 1985. Robbins also reports, without evaluation, Fish and Wildlife Service accusations against the Peregrine Fund that originated with the German Lothar Ciesielski and appear to be based on nothing but hearsay and conjecture. It is not only disconcerting that the Law Enforcement Division of the Fish and Wildlife Service has been broadcasting derogatory statements from a source of such dubious credibility, thus risking serious damage to the Peregrine Fund's effective program to restore an endangered species, but also that Robbins has been willing to spread them further. If those statements cause even a 10 percent decrease in donations to the Peregrine Fund, the Service will have done more damage to the wild peregrine population by reducing the rate of release of captive-bred peregrines to the wild than all the illegal taking described in the Service's claims—claims we believe to be greatly exaggerated.

Williston Shor
North American Falconers Association
Mill Valley, California

Jim Robbins replies:

I took great pains to point out that the information on the Peregrine Fund was hearsay. Because the reputation of the Fund had already been damaged to the point that it had lost funding, I felt this was an opportunity for Fund officials to air their side of the story. In my mind, the Peregrine Fund remains a professional organization that is crucial to the restoration of the peregrine falcon in the Un States.

In Good Odor

In "Stowaways on the Hummingl Express" (July 1985), Robert K. Col denigrates the human sense of smell. F he read Trygg Engen's 1982 book, *Perception of Odors*, Colwell would k better. The human nose is exquisitely sitive to many odors and plays an im tant (if generally misunderstood) rol human affairs. One reason we tend to derestimate the importance of olfact Engen notes, is that most sensory input the nose go directly to the emotional c ters of the brain, not to the cortex. Th the influence of smells on human cho and activities is typically unconscious.

James V. McCon
Ann Arbor, Michi

Robert K. Colwell replies:

As a lover of wine, food, and cook and as a firm believer in the role of hun pheromones in daily life, I certainly not intend to "denigrate" the human se of smell in any absolute sense. Nonet less, an hour spent watching coatimun in a tropical forest, or even just a walk the woods with the family dog, is olfactorily humbling experience. Hum perception of odors is without doubt derrated, but isn't it curious that we one who cannot see "blind," and one w cannot hear "deaf," yet there is no w in our common speech for the inability smell?

The contrast I intended in "St aways," however, was not so much tween human and other animals, but tween the sensory world of hummingb flower mites—which see nothing—a the sensory world of hummingbirds which smell nothing (as far as we kno

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Fifty Years of Astronomy

Hayden Planetarium reaches the half-century mark

by Isaac Asimov

In October 1935, the Hayden Planetarium opened. Astronomy seemed a highly developed subject. There were huge telescopes. Distant Pluto had been discovered. The universe contained vast numbers of galaxies, each as crowded with stars as our own Milky Way, and the whole of it was expanding. It seemed there was little more to expect.

As it happened, however, astronomy was entering its golden age. Fifty years of revolutionary development lay ahead. So much has taken place that we can only sketch the major developments here.

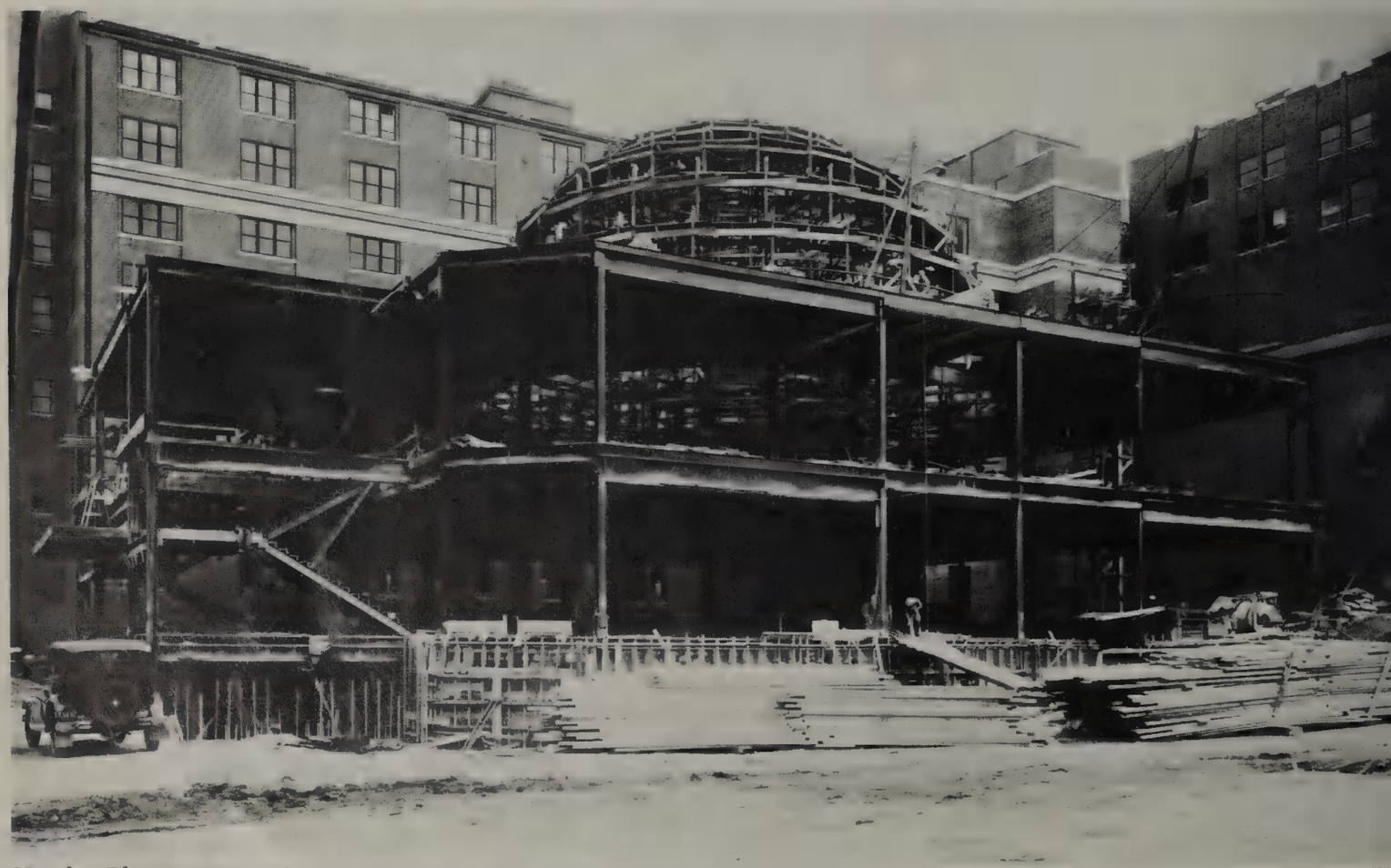
The most familiar astronomical body is, of course, the earth itself, but in 1935 we knew surprisingly little of its geological development. In 1953, however, the Great Global Rift was discovered, and with time it came to be realized that the earth's crust consisted of half a dozen large plates, with a number of smaller ones, all well fitted together and all in very slow motion. It was these plates and their motions (plate tectonics) that accounted for mountain building, island chains, earthquakes, and volcanoes. They even helped explain the course of evolution.

Human beings hurled themselves off the earth, too, something no one but a few science fiction writers took seriously in 1935. The first artificial satellite was launched in 1957. A probe went around the moon in 1959 and sent back the first photographs of the far side, something no human being had ever seen until then. Eventually, the entire moon was mapped in as nearly great detail as the earth is.

In 1961, the first man was placed in orbit, and in 1969, the first men set foot on the moon. Eventually, many pounds of moon rocks were brought back to the earth, and the moon became part of the human range.

The advent of rockets and probes advanced our knowledge of the solar system as has nothing else since the invention of the telescope. For three-quarters of a century, it was thought that Mercury and Ve
nus faced one side to the sun at all time
and had days as long as their years. I
1965, radar reflections from Mercury'
surface showed that it revolved in two
thirds of its year. Every portion of its su
face had both day and night. Similar stud
ies of Venus showed that the length of it
day was *longer* that that of its year an
that it rotated in the "wrong" directio
from east to west. Moreover, microwav
radiation from Venus was detected an
gave the first hint that it was hotter tha
had been thought. The surface tempera
ture throughout the planet is hot enoug
to melt lead so that there is no liquid wate
on it. Its thick, unbroken cloud layer
composed of dilute sulfuric acid, and i
atmosphere, ninety times the density
the earth's, is mostly carbon dioxide.

Probes have mapped most of Mercury
surface in detail, and radar observatio
has mapped Venus's surface rathe
crudely. Probes have also studied Ma



Hayden Planetarium under construction in 1934, one year before it opened

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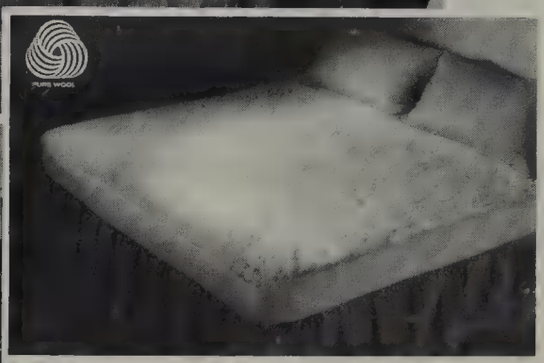

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and, in 1976, even landed on it. The long dreamed of canals of Mars do not exist, but craters do. (Indeed, craters exist on every airless world, with a few understood exceptions.) Extinct volcanoes also exist on Mars (and possibly on Venus). Mars's atmosphere is one percent as thick as the earth's and is mostly carbon dioxide. Its temperature is as low as that of Antarctica. Analysis of Martian soil makes it doubtful that any life exists there.

Finally, probes have taken photographs of Jupiter and Saturn at close quarters and shown us those giants in far greater detail than could be hoped for from Earth-based observations. In a way, the surroundings of the planets were the subject of more startling discoveries than the planets themselves were.

Jupiter was surrounded by a giant magnetic field containing charged particles that would make human exploration extremely difficult, if not impossible, and it also possessed a thin ring of debris invisible from the earth. Ganymede and Callisto, its two giant outer satellites, were cratered and icy. Europa, the smallest of the four giants, was covered with a worldwide glacier, crisscrossed by cracks, and probably had a liquid ocean beneath. Io was the great surprise. It had active volcanoes that spewed out sulfur so that the surface was red-orange in color.

The great surprise in connection with Saturn was its rings, which turned out to be extraordinarily complex, being made up of hundreds or even thousands of concentric ringlets. Dark "spokes" were present, and some of the ringlets even seemed "braided." Much of the detail of the rings remains to be explained. Titan, the largest Saturnian satellite, was thought, from Earth-based observations, to have a thin, methane atmosphere but was found to have one that was smoggy, half again as dense as the earth's, and consisting mostly of nitrogen.

Probes have not yet reached beyond Saturn, but since 1935, Earth-based studies have discovered a fifth satellite of Uranus and a second satellite of Neptune. In 1977, a large asteroid, Chiron, was discovered, with an orbit that carried it from the neighborhood of Saturn out to that of Uranus. In 1978, Pluto was found to have a satellite, named Charon, almost as large as the planet itself. Pluto turned out to be far smaller than it was thought to be when first discovered. It is considerably smaller than our moon.

In 1935, the source of the sun's energy still had an air of mystery about it. In 1938, however, the details of the hydrogen fusion at its center seemed to have been worked out.

In 1958, it became clear that a constant spray of rapid charged particles was emerging from the sun in all directions, the so-called solar wind. Also emerging from the sun in all directions are particles called neutrinos (which were only mentioned in theory in 1935 and which very few took seriously). These solar neutrinos emerge from the fusion regions at the center and could tell us a great deal about the workings of the sun if they could be properly trapped and studied. Attempts were made in the 1970s and 1980s, but so far, only one-third of the expected number of neutrinos have been found—which may mean that we don't yet have the correct information about what goes on in the center of the sun.

Another point of uncertainty concerning the sun is the verification of the Maunder minimum, which had first been suggested back in the 1890s but which no one then took seriously. Apparently, the sun goes through decades-long periods in which there are virtually no sunspots. This evidently affects the earth's weather, for the last Maunder minimum (1645 to 1715) seems to have coincided with a siege of unusually cold temperatures. We must therefore take seriously the effect upon us of a sun far less stable and well behaved than it was thought to be in 1935.

In studying the universe outside our solar system, we began by being dependent only on the light radiated from the stars. Although astronomers developed the use of telescopes, spectroscopes, and cameras, the basic information still came from light—even in 1935, when the Hayden Planetarium was opened.

To be sure, radio waves from the stars were discovered in 1931, but it was not until after World War II that the technique of detecting such waves was sufficiently developed to make radio astronomy a important branch of the science.

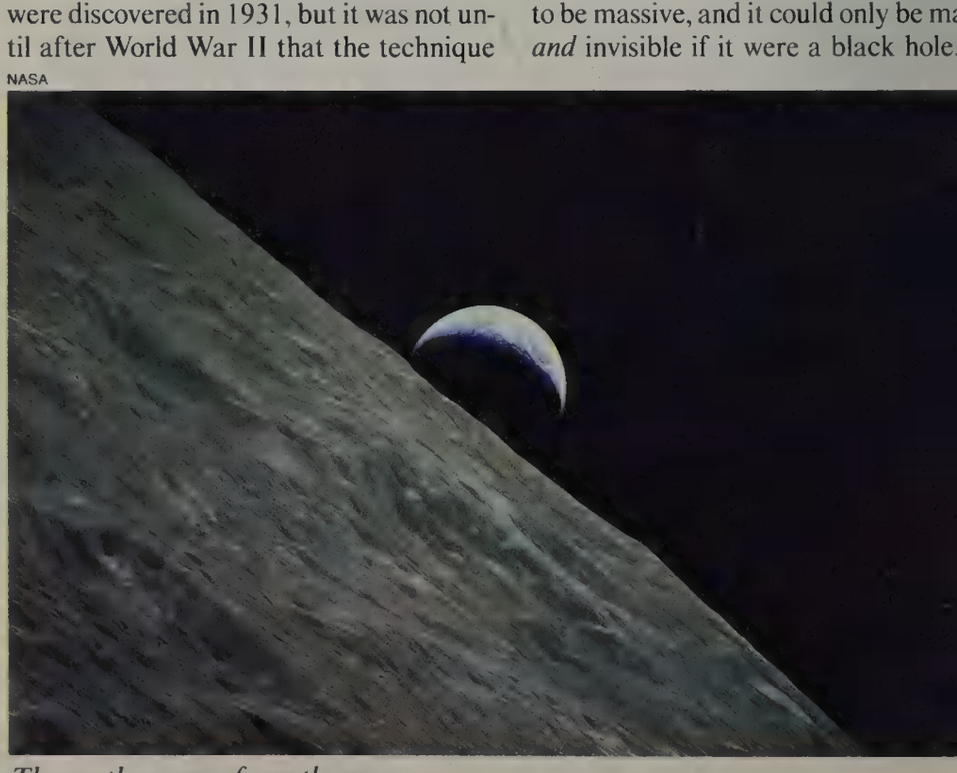
In 1969, an entirely new kind of was detected through radiotelesc Rapid radio pulsations with a period i second range were discovered and see to originate in what were called puls stars, or pulsars. More and more of were detected in the sky, and a cons ation of the properties of those pulse to the realization that pulsars were tron stars.

Neutron stars had first been spok as possible out of purely theoretical soning in 1934, a year before the Ha Planetarium was founded, but they not taken seriously. Now they are k to exist. They are extremely compr stars, the remnants of supernova e sions, made up of neutrons in conta that a star of the mass of our sun wou condensed into an object only about miles across.

An even more condensed object w be a black hole. This would be a sta any object) that would be condens the point where even neutrons w smash together and break down so the resultant matter would collapse t volume (a "singularity"). The existen black holes was first suggested in but there was no chance of detectin until satellites were designed launched beyond the earth's atmos for the purpose of picking up X-rays space.

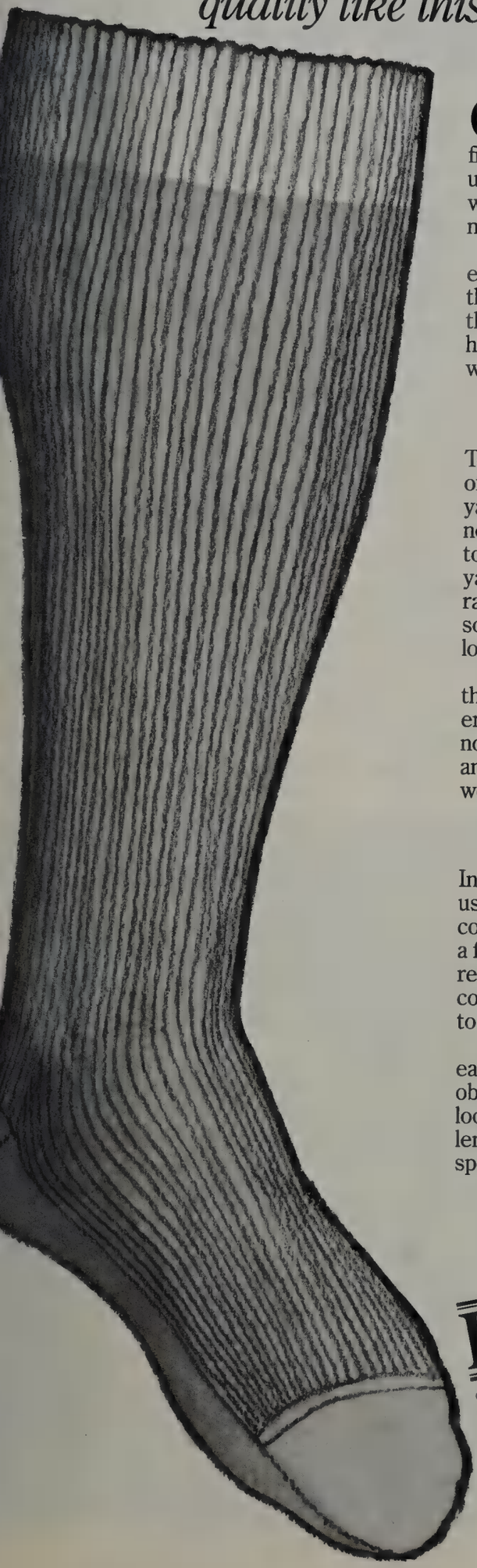
In 1971, an X-ray source called Cy X-1 was found to be an invisible obje cling a massive star. From the natu the orbit, the X-ray source was itself to be massive, and it could only be ma *and* invisible if it were a black hole.

NASA



The earth as seen from the moon

Before you say $11.50 is too much to pay for these Lands' End socks, remember: *quality like this comes only from France.*



Our search for the finest quality men's sock we could find—the kind of search typical of us at Lands' End—took us all the way to the Dore Dore knitting mills in France.

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Radio astronomy has shown that many galaxies are "active"; that is, they are unusually strong radio emitters. Such emissions tend to come from various jets extending from a galaxy's center. Some galaxies actually seem to be exploding. Even quiet galaxies, such as our own, have concentrated spots at the center that emit radio-wave radiation in considerable quantities. Apparently, black holes may exist at the center of most, if not all, galaxies, and even, possibly, at the center of globular clusters.

Under those conditions, the placid appearance of the night sky as seen by light alone, whether by eye or telescope, is, in a sense, a sham. By means of instruments that have only become available to us in the last generation, the universe appears to be an unimaginably violent place. It may even be that in most areas life as we know it would be impossible, and we are alive only because our sun circles the galactic center in an orbit that keeps it safely in the spiral arm outskirts.

Some radio sources seemed at first to be rather dim stars in our own galaxy, and this made them unusual indeed since the vast majority of stars did not emit detectable quantities of radio waves. Astronomers suspected, therefore, that they were something more than stars, and they were named quasistellar (that is, starlike) radio sources, or, for short, quasars.

In 1963, these quasars were found to be far more than they seemed to be, for their peculiar spectra turned out to consist of lines shifted unbelievably far toward the red. These enormous red shifts meant that quasars are tremendously far away—a billion light-years and more. They are, in fact, farther off than any of the visible galaxies and are the farthest objects known. Some quasars are more than ten billion light-years away from us.

Some pulsars exist in pairs and revolve about each other. Some quasars exist behind galaxies that lie between us and them. The manner in which pulsars, under such conditions, slow down and quasars, under such conditions, yield images that seem to split in two or more parts offers proof that Einstein's general theory of relativity is correct. This is excellent evidence, yet it involves objects not known to exist at the time that Einstein evolved his theory.

As for the universe as a whole, it was known as far back as 1935 to expand, and there was a suggestion that it began many billions of years ago in the form of a giant explosion. This big bang, however, had no real evidence to support it, and in 1948, a competing theory of continuous creation (the slow creation of matter that formed new galaxies between older galaxies that pulled away from each other) was introduced.

In 1949, scientists suggested that if the big bang had taken place, the fiery energies that existed at first would have spread out and cooled down as the universe expanded. Nowadays, those energies w
exist as radio-wave radiation co
equally from all parts of the sky—the
of radio waves that would be expecte
temperature near absolute zero.

In 1964, precisely this sort of r
wave radiation was detected, and nc
most all astronomers accept the big
theory of the beginnings of the univ
The details of the big bang are still u
discussion, however. The important
tions about the big bang deal with th
cific events that took place in the t
fractions of a second after the actua
ginning.

To understand those events, adv
had to be made in our understandi
the most basic particles of matter. I
1970s, new theories about these par
were worked out, and these theories
used, in turn, to work out the scena
what is called the inflationary univ
which explains a great many things
the evolution of the galaxies and the
eral properties of the universe tha
been murky before.

And so from the earth to the fa
bounds and earliest times of the uni
our understanding has grown enorm
in the last half-century. Subtract a
have learned in that time and our k
edge of astronomy in 1935 would
small indeed.

*Isaac Asimov has written more tha
books, dozens of them on astronon*

High Altitude Observatory and NASA

An artificially colored photograph of the sun's corona with the solar disk deliberately blocked out

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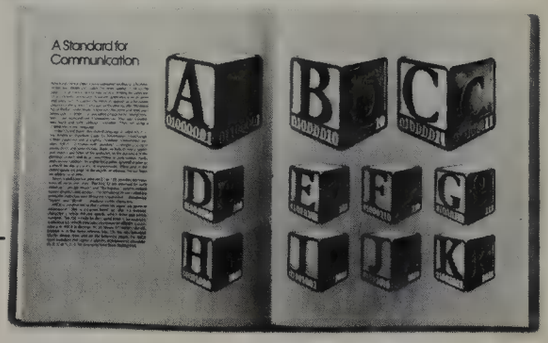

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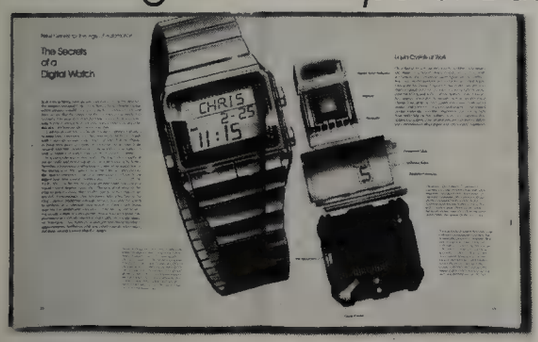

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UNDERSTANDING COMPUTERS

Not Necessarily a Wing

Which came first, the function or the form?

by Stephen Jay Gould

From *Flesh Gordon* to *Alex in Wonderland*, title parodies have been a stock-in-trade of low comedy. We may not anticipate a tactical similarity between the mayhem of *Mad* magazine's movie reviews and the titles of major scientific works, yet two important nineteenth-century critiques of Darwin parodied his most famous phrases in their headings.

In 1887, E.D. Cope, the American paleontologist known best for his fossil feud with O.C. Marsh but a celebrated evolutionary theorist in his own right, published *The Origin of the Fittest*—a takeoff on Herbert Spencer's phrase, borrowed by Darwin as the epigram for natural selection: survival of the fittest. (Natural selection, Cope argued, could only preserve favorable traits that must arise in some other manner, unknown to Darwin. The dilemma of evolution became, therefore, not the differential survival of adaptive traits, but their unexplained origin—hence the title parody.)

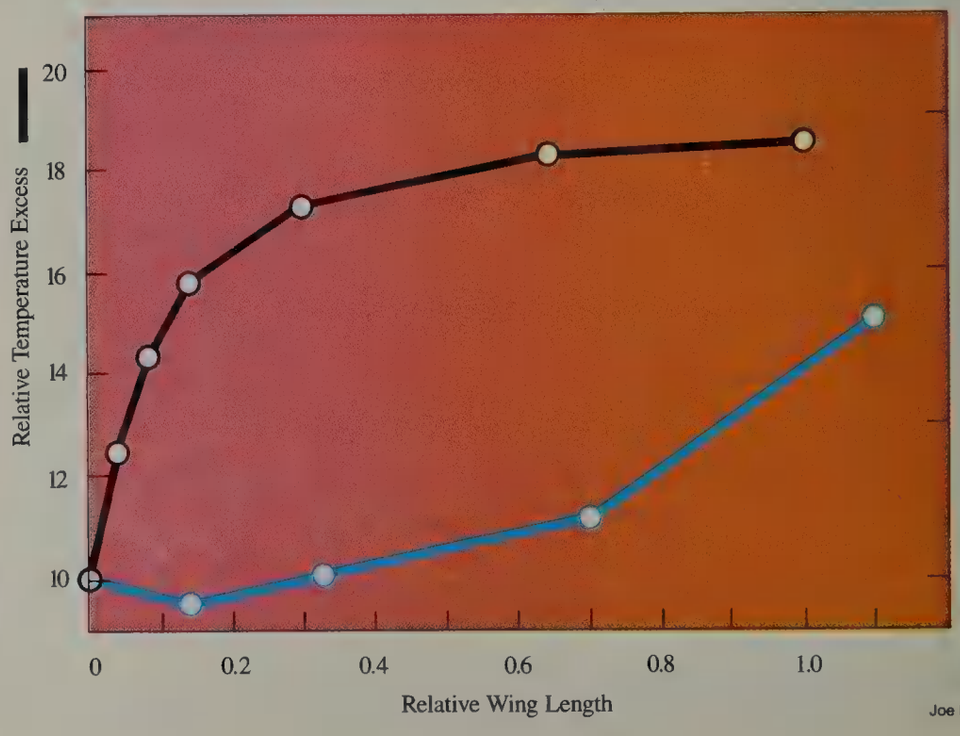
St. George Mivart (1817–1900), a fine British zoologist, tried to reconcile his unconventional views on religion and biology but ended his life in tragedy, rejected by both camps. At age seventeen, he abandoned his Anglican upbringing, became a Roman Catholic, and consequently (in a less tolerant age of state religion) lost his opportunity for training in natural history at Oxford or Cambridge. He became a lawyer but managed to carve out a distinguished career as an anatomist nonetheless. He embraced evolution and was befriended by the powerful T.H. Huxley, but his strongly expressed and idiosyncratic anti-Darwinian views led to his rejection by the biological establishment of Britain. He tried to unite his biology with his religion in a series of books and essays and ended up excommunicated for his trouble six weeks before his death.

Mivart shared Cope's major criticism of Darwin—that natural selection could explain the preservation and increase of favored traits but not their origin. But he went gunning for a higher target than Darwin's epigram. He shot for the title itself, naming his major book (1871) *On the Genesis of Species*. (Darwin, of course, had called his classic *On the Origin of Species*.)

Mivart's life may have ended in sadness and rejection thirty years later, but his *Genesis of Species* had a major impa its time. Darwin himself offered stro grudging, praise and took Mivart far seriously than any other critic, even ing a chapter to later editions of the *O of Species* primarily to counter Mi attack.

Mivart gathered, and illustrated admirable art and force" (Dar words), all objections to the theory o ural selection—"a formidable a (Darwin's words again). Yet one pa lar theme, urged with special attenti Mivart, stood out as the centerpiece criticism. It remains today the pri stumbling block among thoughtful

The Evolution of Insect Wings



Joe L

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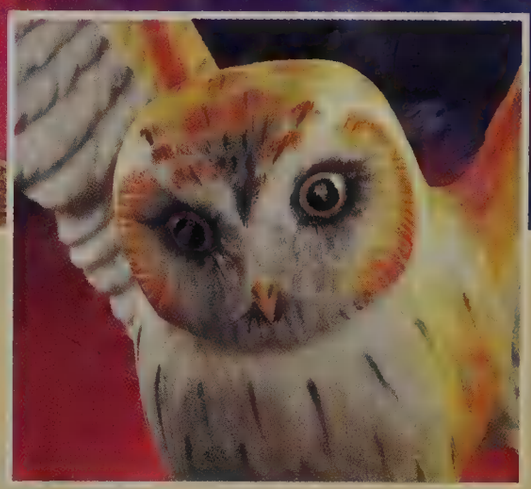

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friendly scrutinizers of Darwinism. I other criticism seems so troubling, so ob ously and evidently "right" (against Darwinian claim that seems intuitive paradoxical and improbable).

Mivart awarded this criticism a sep rate chapter in his book, right after the troduction. He also gave it a name, membered ever since. He called it "T Incompetency of 'Natural Selection' Account for the Incipient Stages of Us ful Structures." If this phrase sounds li a mouthful, consider the easy translatio we can readily understand how compl and fully developed structures work a owe their maintenance and preservation natural selection—a wing, an eye, the semblance of a bittern to a branch or of insect to a stick or dead leaf. But how you get from nothing to such an elabora something if evolution must proce through a long sequence of intermedia stages, each favored by natural selectio You can't fly with 2 percent of a wing gain much protection from an iota's sim larity with a potentially concealing pie of vegetation. How, in other words, c natural selection explain these incipie stages of structures that can only be us (as we now observe them) in much mo elaborated form?

I have treated this issue in many pre ous essays—and for a definite, impos reason. I receive an enormous volume mail from sincere and thoughtful reade who are trying to work through the co plexities of evolution and run adrift on o argument or another. (Often, of course cannot help because we professionals a adrift ourselves in many areas.) I ha made a semiformal tally of these reefs a shoals, and one point stands high abo the rest: the dilemma of incipient stag Mivart identified this problem as prima and it remains so today.

I take up this subject again for two re sons. First, I believe that Darwinism h and has long had, an adequate and int esting resolution to Mivart's challenge (though we have obviously been blessed unsuccessful in getting it across). Secon a paper just published in the technic journal *Evolution* has provided comp ling experimental evidence for this reso tion applied to its most famous case—t origin of wings.

The dilemma of wings—perhaps t standard illustration of Mivart's telli point about incipient stages—is set for particularly well in a perceptive letter th I received from a reader just last week medical doctor in California. He write

How does evolutionary theory as und stood by Darwin explain the emergence items such as wings, since a small move

rd a wing could hardly promote survival? eem to be stuck with the idea that a sig- ıcant quality of wing would have to ing forth all at once to have any survival ue.

Interestingly, my reader's proposal that ıch or most of the wing must arise all at ce because incipient stages could have adaptive value follows Mivart's own olution. Mivart first enunciated the ıeral dilemma (1871, p. 23):

tural selection utterly fails to account the conservation and development of the nute and rudimentary beginnings, the ght and infinitesimal commencements of uctures, however useful those structures y afterwards become.

After fifty pages of illustration, he con- des: "Arguments may yet be advanced favor of the view that new species have m time to time manifested themselves h suddenness, and by modifications ap- aring at once." Advocating this general ution for wings in particular, he con- des (p. 107): "It is difficult, then, to be- ve that the Avian limb was developed in y other way than by a comparatively lden modification of a marked and im- tant kind."

Darwin's theory is rooted in the proposi- n that natural selection is the primary ative force in evolutionary change. is creativity will be expressed only if the tuitous variation forming the raw mate- l of evolutionary change can be accu- lated sequentially in tiny doses, with ural selection acting as the sieve of ac- otance. If new species arise all at once in occasional lucky gulp, then selection s no creative role. Selection, at best, be- nes an executioner, eliminating the un- following this burst of good fortune. us, Mivart's solution—bypassing incip- t stages entirely in a grand evolutionary p—has always been viewed, quite htly, as an anti-Darwinian version of olutionary theory.

Darwin well appreciated the force, and entially devastating extent, of Mivart's tique about incipient stages. He coun- attacked with gusto, invoking the stan- rd example of wings and arguing that vart's solution of sudden change pre- ted more problems than it solved—for w can we believe that so complex a ucture as a wing, made of so many co- inated and coadapted parts, could se all at once:

who believes that some ancient form s transformed suddenly through an inter- force or tendency into, for instance, one nished with wings, will be . . . compelled believe that many structures beautifully

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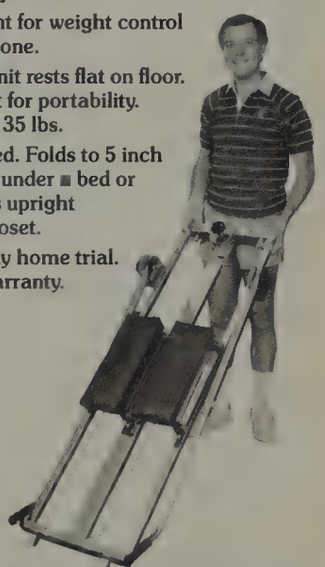

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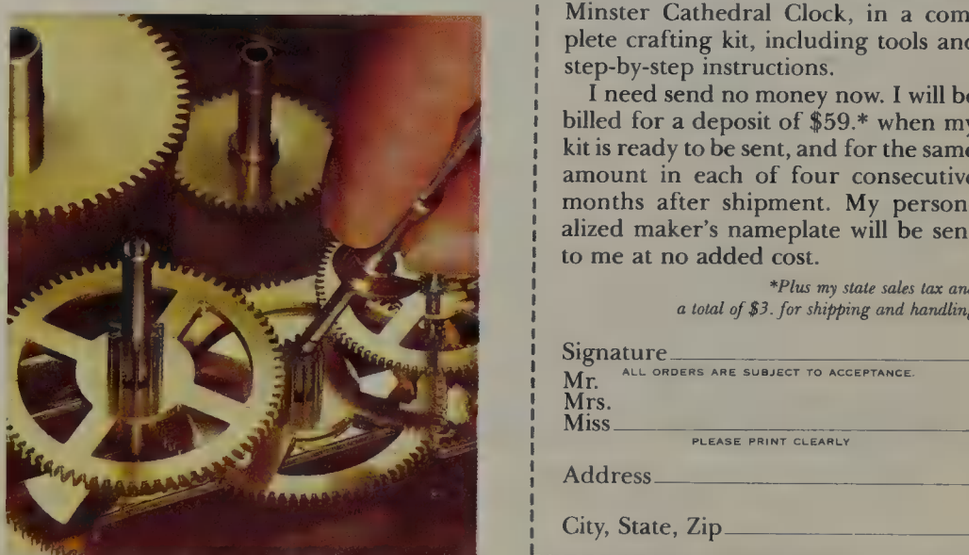

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adapted to all the other parts of the same creature and to the surrounding conditions, have been suddenly produced; and of such complex and wonderful co-adaptations, he will not be able to assign a shadow of an explanation .... To admit all this is, as it seems to me, to enter into the realms of miracle, and to leave those of Science.

(This essay must now go in other directions but not without a small, tangential word in Mivart's defense. Mivart did appreciate the problem of complexity and coordination in sudden origins. He did not think that any old complex set of changes could arise all at once when needed—*that* would be tantamount to miracle. Most of Mivart's book studies the regularities of embryology and comparative anatomy to learn which kinds of complex changes might be possible as expressions and elaborations of developmental programs already present in ancestors. He advocates these changes as possible and eliminates others as fanciful.)

Darwin then faced his dilemma and developed the interestingly paradoxical resolution that has been orthodox ever since (but more poorly understood and appreciated than any other principle in evolutionary theory). If complexity precludes sudden origin, and the dilemma of incipient stages forbids gradual development in functional continuity, then how can we ever get from here to there? Darwin replies that we must reject an unnecessary hidden assumption in this argument—the notion of functional continuity. We will all freely grant that no creature can fly with 2 percent of a wing, but why must the incipient stages be used for flight? If incipient stages originally performed a different function suited to their small size and minimal development, natural selection might superintend their increase as adaptations for this original role until they reached a stage suitable for their current use. In other words, the problem of incipient stages disappears because these early steps were not inadequate wings but well-adapted something-elses. This principle of *functional change in structural continuity* represents Darwin's elegant solution to the dilemma of incipient stages.

Darwin, in a *beau geste* of argument, even thanked Mivart for characterizing the dilemma so well—all the better to grant Darwin a chance to elaborate his solution. Darwin writes: "A good opportunity has thus been afforded [by Mivart] for enlarging a little on gradations of structure, often associated with changed functions—an important subject, which was not treated at sufficient length in the former editions of this work." Darwin, who rarely added intensifiers to his prose, felt so strongly about this principle of functional shift that he wrote: "In considering transitions of organs, it is so important to bear in mind the probability of conversion from one function to another."

Darwin presented numerous examples in chapters 5 and 7 of the final edition of the *Origin of Species*. He discussed organs that perform two functions, one primary, the other subsidiary, then relinquish the main use and elaborate the formerly inconspicuous operation. He then examined the flip side of this phenomenon—functions performed by two separate organs (fishes breathing with both lungs and gills). He argues that one organ may assume the entire function, leaving the other free for evolution to some other role (lungs for conversion to air bladders, for example, with respiration maintained entirely by gills). He does not, of course, neglect the classic example of wings, arguing that insects evolved their organs of flight from tracheae (or breathing organs—a minority theory today, but not without supporters). He writes: "It is therefore highly probable that in this great class organs which once served for respiration have been actually converted into organs of flight."

Darwin's critical theory of functional shift, usually (and most unfortunately) called the principle of "preadaptation,"* has been with us for a century. I believe that this principle has made so little headway, not primarily because it is paradoxical and difficult, but mainly because we have so little firm, direct evidence for such functional shifts. Our technical literature contains many facile verbal arguments—little more than plausible "just-so" stories. The fossil record also presents some excellent examples of sequential development through intermediary stages that could not work as modern organs do—but we lack a rigorous mechanical analysis function at the various stages.

Let us return, as we must, to the clas case of wings. *Archaeopteryx*, the fi bird, is as pretty an intermediate as leontology could ever hope to find— complex mélange of reptilian and avi features. Scientists are still arguing abo whether or not it could fly—if so, worked like the Wrights' biplane to a mo ern eagle's Concorde. But what did the discovered ancestors of *Archaeopteryx* with wing rudiments that surely could fly? Evolutionists have been invoking D win's principle of functional shift for mo than 100 years, and the list of proposals long. Protowings have been reconstruct as stabilizers, sexual attractors, or inse catchers. But the most popular hypothe identifies thermoregulation as the origi function of incipient stages that la evolved into feathered wings. Feathers modified reptilian scales, and they wo very well as insulating devices. Moreov if birds evolved from dinosaurs (as m paleontologists now believe), they ar from a lineage particularly subject problems with temperature control. *chaeopteryx* is smaller than any dinos and probably arose from the tiniest of nosaur lineages. Small animals, as a con quence of high ratios of surface area volume, lose heat rapidly and may requ supplementary devices for thermoregu tion. Most dinosaurs could probably ke warm enough just by being large. Surf area (length × length, or length squar increases more slowly than volume (leng × length × length, or length cubed) as jects grow. Since animals generate h over their volumes and lose it throu their surfaces, small animals (with th relatively large surface areas) have m trouble keeping warm.

There I go again—doing what I j criticized. I have presented a plausi

*This dreadful name has made a difficult principle even harder to grasp and understand. Preadaptation seems to imply that the protowing, while doing something else in its incipient stages, knew where it was going—predestined for a later conversion to flight. Textbooks usually introduce the word and then quickly disclaim any odor of foreordination. (But a name is obviously ill-chosen if it cannot be used without denying its literal meaning.) Of course, by "preadaptation" we only mean that some structures are fortuitously suited to other roles if elaborated, not that they arise with a different, future use in view—now there I go with the standard disclaimer. As another important limitation, preadaptation does not cover the important class of features that arise without functions (as developmental consequences of other primary adaptatio for example) but remain available for la co-optation. I suspect, for example, t many important functions of the hun brain are co-opted consequences of build such a large computer for a limited se adaptive uses. For these reasons, Elizab Vrba and I have proposed that the rest tive and confusing word preadaptation dropped in favor of the more inclusive te exaptation—for any organ not evolved der natural selection for its current use— ther because it performed a different fu tion in ancestors (classical preadaptati or because it represented a nonfunctio part available for later co-optation. See technical article, "Exaptation: A Miss Term in the Science of Form," Paleob ogy, vol. 8, 1981).

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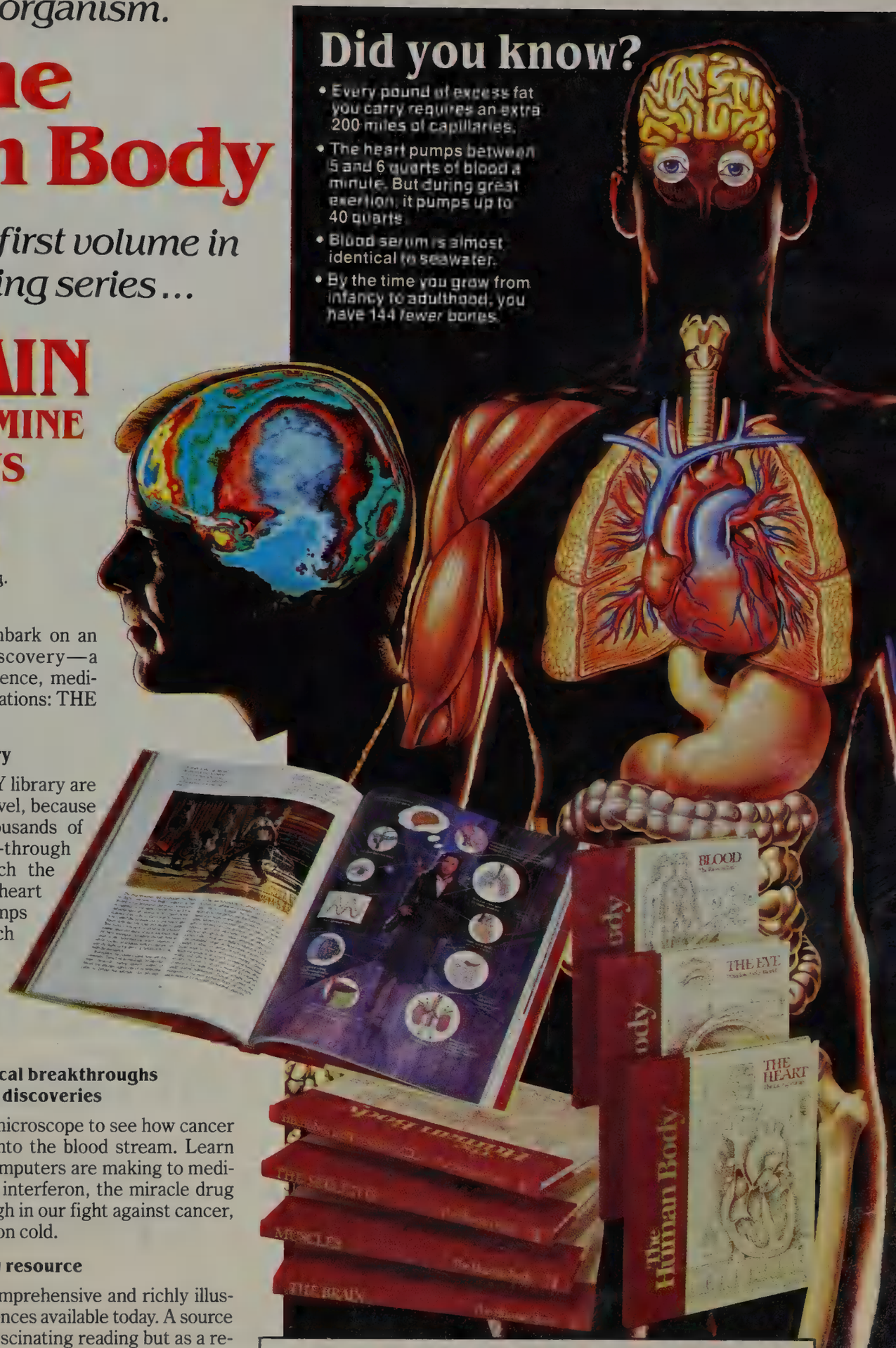

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ry about thermoregulation as the origi- function of organs that later evolved o wings—but where's the chicken, or otochicken. Science is tested evidence, t tall tales. This lamentable mode has en traditionally used to illustrate Dar- n's principle of functional shift only *ute de mieux*—because we didn't have e goods so ardently desired. At least un- last month, when my colleagues Joel G. ngsolver and M.A.R. Koehl published e first hard evidence to support a shift m thermoregulation to flight as a sce- rio for the evolution of wings. They died insects, not birds—but the same gument has long been favored for na- e's smaller and far more abundant ngs (see their article, "Aerodynamics, ermoregulation, and the Evolution of sect Wings: Differential Scaling and olutionary Change," in *Evolution*, vol. , 1985, pp. 488–504).

In preparing this essay, I spent several ys reading the classical literature on the lution of insect flight—and emerged h a deeper understanding of just how ficult Darwin's principle of functional ft can be, even for professionals. Most the literature hasn't even reached the t base of applying functional shift in first place, not to mention the later sta- ns of substituting direct evidence for bal speculation. Most reconstructions still trying to explain the incipient ges of insect wings as somehow in- ved in airborne performance from the rt—not for flapping flight, of course, t still for some aspect of motion aloft her than, as Darwin's principle would ggest, for some quite different function. To appreciate the dilemma of such a po- on (so well grasped by Mivart more n 100 years ago), consider just one re- nt study (probably the best and most dely cited) and the logical quandaries t a claim of functional continuity en- ls. In 1964, J.W. Flower (in the *Journal Insect Physiology*) presented aerody- mic arguments for wings evolved from iest first to elaborate last in the interest airborne motion. Flower argues, sup- ting an orthodox view, that wings lved from tiny outgrowths of the body d for gliding prior to elaboration for tained flight. But Flower recognizes t these incipient structures must them- ves evolve from antecedents too small function as gliding planes. What could se very first, slight outgrowths of the dy be for? Ignoring Darwin's principle functional shift, Flower searches for an odynamic meaning even at this very set. He tries to test two suggestions: H. Hinton's argument that initial out- wths served for "attitude control," per- mitting a falling insect to land in a suitable position for quick escape from predators; and a proposal of the great British entomologist Sir Vincent Wigglesworth (wonderful name for an insect man, I always thought) that such first stages might act as stabilizing or controlling devices during takeoff in small, passively aerial insects.

Flower proceeded by performing aerodynamic calculations on consequences of incipient wings to simple body shapes when dropped—and he quickly argued himself into an inextricable logical corner. He found, first of all, that tiny outgrowths might help, as Wigglesworth, Hinton, and others had suggested. But the argument foundered on another observation: the same advantages could be far more easily and effectively gained by another, readily available alternative route—evolution to small size (where increased surface/volume ratios retard falling and enhance the probability of takeoff). Flower then realized that he would have to specify a reasonably large body size for incipient wings to have any aerodynamic effect. But he then encountered another problem: at such sizes, legs work just as well as, if not better than, protowings for any suggested aerodynamic function. Flower admitted:

> The first conclusion to be drawn from these calculations is that the selective pressure in small insects is towards smaller insects, which would have no reason to evolve wings.

I would have stopped and searched elsewhere (in Darwin's principle of functional shift) at this point, but Flower bravely continued along an improbable path:

> The main conclusions, however, are that attitude control of insects would be by the use of legs or by very small changes in body shape.

As a general rule in science, one should examine basic premises when arguments founder. But Flower never considered an alternative to his assumption of functional continuity based upon some aspect of aerial locomotion. He concluded:

> At first they [protowings] would affect attitude; later they could increase to a larger size and act as a true wing, providing lift in their own right. Eventually they could move, giving the insect greater maneuverability during descent, and finally they could "flap," achieving sustained flight.

As an alternative to such speculative reconstructions that work, in their own terms, only by uncomfortable special pleading, may I suggest Darwin's old principle of functional shift (preadaptation—ugh—for something else).

The physiological literature contains voluminous testimony to the thermody-

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namic efficiency of modern insect wings: in presenting, for example, a large surface area to the sun for quick heating (see B. Heinrich, *Insect Thermoregulation*, Academic Press, New York, 1981). If wings can perform this subsidiary function now, why not suspect thermoregulation as a primary role at the outset? M.M. Douglas, for example (*Science*, 1981, vol. 211, pp. 84–86), showed that, in *Colias* butterflies, only the basal one-third of the wing operates in thermoregulation—an area approximately equal to the thoracic lobes (protowings) of fossil insects considered ancestral to modern forms.

Douglas then cut down some *Colias* wings to the actual size of these fossil ancestral lobes and found that insects so bedecked showed a 55 percent greater increase in body temperature than bodies deprived of wings entirely. These manufactured protowings measured 5 by 3 millimeters on a body 15 millimeters long. Finally, Douglas determined that no further thermoregulatory advantage could be gained by wings longer than 10 millimeters on a 15-millimeter body.

Kingsolver and Koehl performed a host of elaborate and elegant experiments to support a thermoregulatory origin of insect protowings. As with so many exa ples of excellent science producing cl and interesting outcomes, the results c be summarized briefly and cleanly.

Kingsolver and Koehl begin by tabul ing all the aerodynamic hypotheses u ally presented in the literature as pur verbal speculations. They arrange th proposals of functional continuity (the planations that do not follow Darwin's lution of Mivart's dilemma) into three sic categories: protowings for glidi (aerofoils for steady-state motion), parachuting (slowing the rate of desc in a falling insect), and attitude stabil (helping an insect to land right side u They then transcended the purely verb tradition by developing aerodynan equations for exactly how protowi should help an insect under these three potheses of continuity in adaptation creasing the lift/drag ratio as the ma boost to gliding, increasing drag to sl the descent rate in parachuting, meas ing the moment about the body axis p duced by wings for the hypothesis of a tude stability).

They then constructed insect models wire, epoxy, and other appropriate mat als to match the sizes and body shapes flying and nonflying forms among ea insect fossils. To these models, they tached wings (made of copper wire encl ing thin, plastic membranes) of vari lengths and measured the actual aero namic effects for properties predicted various hypotheses of functional conti ity. The results of many experiments wind tunnels are consistent and con nant: aerodynamic benefits begin wings above a certain size, and they crease as wings get larger. But at the sm sizes of insect protowings, aerodynan advantages are absent or insignificant a do not increase with growing wing leng These results are independent of bo shape, wind velocity, presence or pla ment of legs, and mounting position wings. In other words, large wings w well and larger wings work better—l small wings (at the undoubted sizes Mivart's troubling incipient stages) p vide no aerodynamic edge.

Kingsolver and Koehl then tested th models for thermoregulatory effects, c structing wings from two materials w different thermal conductivities (c struction paper and aluminum foil) a measuring the increased temperature bodies supplied with wings of vari lengths versus wingless models. Th achieved results symmetrically oppo to the aerodynamic experiments. For th moregulation, wings work well at smallest sizes, with benefits increasing

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ıe wing grows. However, beyond a mea-
ured length, further increase of the wing
ɔnfers no additional effect. Kingsolver
ıd Koehl conclude:

t any body size, there is a relative wing
ngth above which there is no additional
ermal effect, and below which there is no
gnificant aerodynamic effect.

he accompanying chart illustrates these
ɔmbined results. Note how the thermo-
gulatory effect of excess body tempera-
re due to wings (solid line) increases rap-
ly at small wing sizes but not at all above
ı intermediate wing length. Conversely,
e aerodynamic effect of lift/drag ratio
es not increase at all until intermediate
ng length and grows rapidly thereafter.
We could not hope for a more elegant
perimental confirmation of Darwin's so-
tion to Mivart's challenge. Kingsolver
d Koehl have actually measured the
nctional shift by showing that incipient
ngs aid thermoregulation but provide
aerodynamic benefit—while larger
ngs provide no further thermoregula-
ry oomph but initiate aerodynamic ad-
ntage and increase the benefits steadily
ereafter. The crucial intermediate wing
ngth, where thermoregulatory gain
ases and aerodynamic benefits begin,
presents a domain of functional shift, as aerodynamic advantages pick up the relay from waning thermoregulation to continue the evolutionary race to increasing wing size.

But what might push an insect across the transition? Why reach this crucial domain at all? If wings originally worked primarily for thermoregulation, why not just stop as the length of maximum benefit approached? Here, Kingsolver and Koehl present an interesting speculation based on another aspect of their data. They found that the domain of transition between thermal and aerial effects varied systematically with body size: the larger the body, the sooner the transition (in terms of relative wing length). For a 2-centimeter body length, the transition occurred with wings 40 to 60 percent of body length; but a 10-centimeter body switches to aerodynamic advantage at only 10 percent of body length.

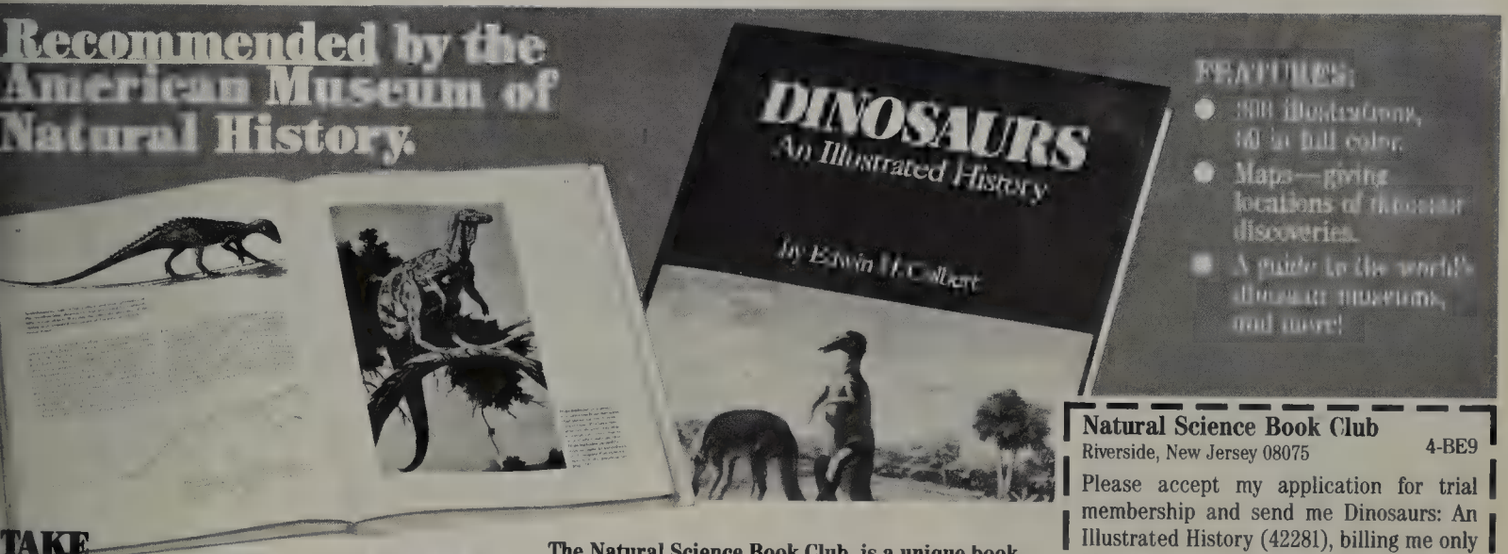
Now suppose that incipient ancestral wings worked primarily for thermoregulation and had reached a stable, optimum size for greatest benefit. Natural selection would not favor larger wings and a transition to the available domain of aerodynamic advantage. But if body size increased for other reasons, an insect might reach the realm of aerial effects simply by growing larger, without any accompanying change of body shape or relative wing length.

We often think, naively, that size itself should make no profound difference. Why should just more of the same have any major effect beyond simple accumulation? Surely, any major improvement or alteration must require an extensive and explicit redesign, a complex reordering of parts with invention of new items.

Nature does not always match our faulty intuitions. Truly complex objects often display the interesting and paradoxical property of major effect for apparently trifling input. Internal complexity can translate a simple quantitative change into a wondrous alteration of quality. Perhaps that greatest and most effective of all evolutionary inventions, the origin of human consciousness, required little more than an increase of brain power to a level where internal connections became rich and varied enough to force this seminal transition. The story may be more complex, but we have no proof that it must be.

Voltaire quipped that "God is always for the big battalions." More is not always better, but more can be very different.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.



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Natural History 10/85

Fossil Ancestors of Burma

To document the origin of the higher primates, paleoanthropologists have retraced the steps of a 1923 expedition

by Russell L. Ciochon

"On the road to Mandalay,/ Where the flyin' fishes play,/ An' the dawn comes up like thunder outer China 'crost the Bay!" So wrote Kipling at the turn of the century of the wonders and enchantment of Burma and its city of Mandalay. Today, as enchanting as ever, the road to Mandalay beckons to paleontologists because Burma is the only place in the world that has yielded fossil evidence of an important link in the primate order. There are two groups of primates on the earth today. The higher primates—monkeys, apes, and humans—are the most familiar. They are sometimes called the Anthropoidea, or humanlike primates. The lower primates—the lemurs, lorises, and tarsiers—make up the second group. These primitive primates, often called Prosimii, or pre-apes, were the first to evolve and were the forerunners of all later forms. However, fossils showing the beginning of the evolutionary branch leading from prosimians to anthropoids have been hard to come by.

An early discoverer of the "Burmese link" that demonstrates this transition was the legendary fossil collector Barnum Brown, a paleontologist at the American Museum of Natural History. In the spring of 1923, Brown and his wife, Lilian, arrived in Rangoon, the capital of Burma. They journeyed by river steamer up the broad, muddy Irrawaddy to the port of Pakokku. From there they mounted a miniexpedition to the little-explored Ponnyadaung (or Pondaung, as Brown spelled it) Hills, located deep in the teak-bamboo forest of Upper Burma. Outfitted with four bullocks, two small, mat-covered carts, and a pair of sway-backed saddle horses, they rode in search of the varicolored sandstones of the Pondaung Formation, rock deposits that had been discovered earlier in the century by British economic geologists. In the words of Lilian Brown, they were "rainbow-ch ing"—following the sedimentary roc shaded yellow, gray, red, purple, a green, seeking a prehistoric pot of gol

When Brown arrived in Burma, vir ally nothing was known about the ea prehistoric life of southern Asia. The p vailing scientific opinion was that A was the mother of all continents, the ce ter of origin for much of the earth's li Brown had been sent by the Americ Museum to collect late Eocene (40- to million-year-old) fossils in support of t "Garden of Eden" theory. He specifica sought to collect large skulls and skelet of extinct animals that could be exhibit at the American Museum.

For two months, Brown's small bullo cart caravan creaked along the dirt trac the only roads in this remote part Burma. Because the resident comm sioner of Burma had provided a letter introduction to all village headmen alo

Lilian Brown, A

In 1923, Barnum Brown (mounted) collected fossils in Burma's Ponnyadaung Hills. This photograph (here tinted) was printe Natural History *in 1925, with a caption noting that the servant Mari (in the cart) died of malaria contracted on the journey.*

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It's estimated that 5 million Americans have diabetes and don't know it. The early symptoms are vague and may seem minor. As a result, they are often ignored or not taken seriously enough. Yet, if undiagnosed, diabetes can lead to serious complications affecting various parts of the body, including eyes, heart, kidneys, brain or even life itself.

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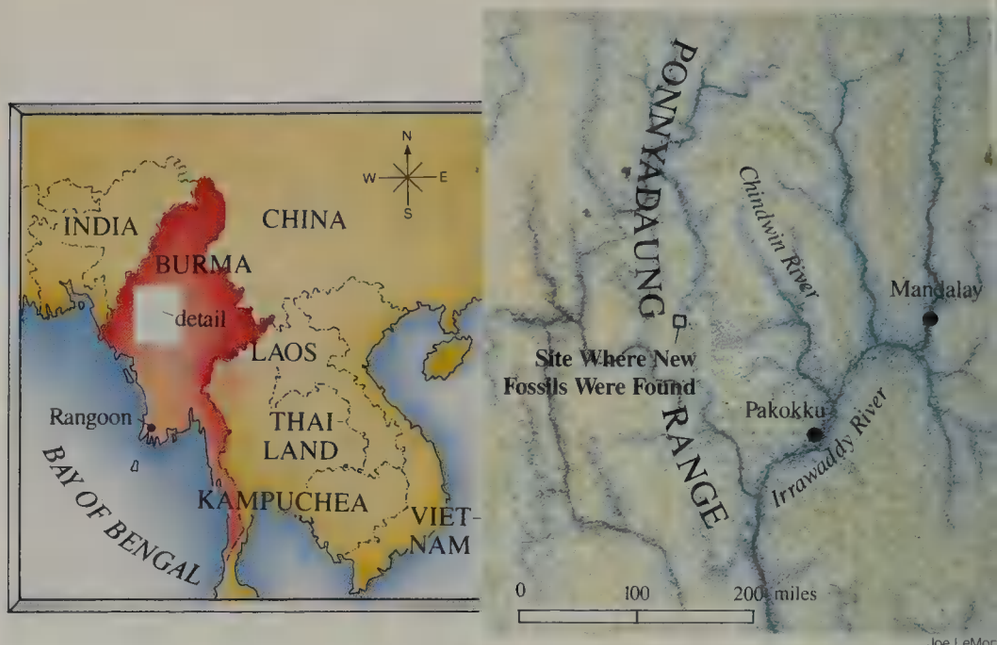

Joe LeMor

the route, Brown was able to camp in villages that were nearest to exposures of the fossil-bearing Pondaung sandstones. One such stop brought him to the outskirts of Mogaung village, where he set up camp with Lilian and their two servants, Mari and Dos. Early each morning Brown would ride off in search of new fossil sites. One day, a short distance northwest of the village, he came upon a locality where he saw a number of small bones and teeth eroding out of the rock. Here he picked up part of a jaw with three teeth—a piece about the size of a fifty cent coin—that belonged to a medium-size primate.

Barnum Brown probably did not realize that what he had discovered was an early higher primate. But Edwin Colbert, Brown's colleague at the American Museum, did, and in 1937 he named the jaw *Amphipithecus mogaungensis* (near-ape of Mogaung). *Amphipithecus* joined the ranks of another Burmese fossil primate, discovered in 1913 by paleontologist G.D.P. Cotter. Cotter had explored the southern exposures of Burma's Ponnyadaung Hills while working for Britain's Geological Survey of India. A description of this specimen (a piece of upper jaw and two pieces of lower jaw) was published in 1927 by Guy Pilgrim, who named it *Pondaungia cotteri*. Pilgrim thought it could be an Eocene higher primate, but the fragments were too scrappy for precise identification. With Colbert's more confident description of *Amphipithecus* in 1937, the late Eocene beds of the Ponnyadaung Hills became known as the source of the earliest record of the Anthropoidea.

Anthropologists debated the evolutionary affinities of *Amphipithecus* and *Pondaungia* for the next four decades. Were they really the world's earliest higher primates or were they prosimians with a few independently evolved anthropoidl features? Was Asia even the place to lo for the origin of the higher primat More fossil evidence was needed, but one was able to work in the Ponnyadau Hills during the years embracing the J anese invasion, World War II, Burm achievement of independence, and emergence of nationalistic policies t followed.

I first visited Burma in 1975, to disc the possibility of a joint U.S.-Burm paleoanthropological research proje With U.S. involvement in the Vietn War drawing to a close, my proposals on receptive ears. After discussing pl with geologists at the Mandalay Arts a Sciences University, I submitted a let to the Ministry of Foreign Affairs. The ply stated that the Ministry had objection to a planned paleontologi visit." On my return to the United Stat teamed up with Donald E. Savage, a s soned paleontologist, and in March 19 having obtained the necessary fund and entry visas, we set off on a two-mo research tour of Burma.

Upon arrival in Rangoon, however, were only given permission to prospect fossils along the Irrawaddy River dra age, where the sediments date from Pleistocene epoch (the last 2 million ye of earth history). Ministry officials clared that the area around the more cient Ponnyadaung Hills was so dang ous that we would need a police esc which could not be provided at the ti Swallowing our disappointment, we f north to Mandalay, where we were met U Ba Maw and U Thaw Tint, our leagues at Mandalay University, al with a geology student who was to be field coordinator, Tin Maung Oo (v likes to be called "Tin").

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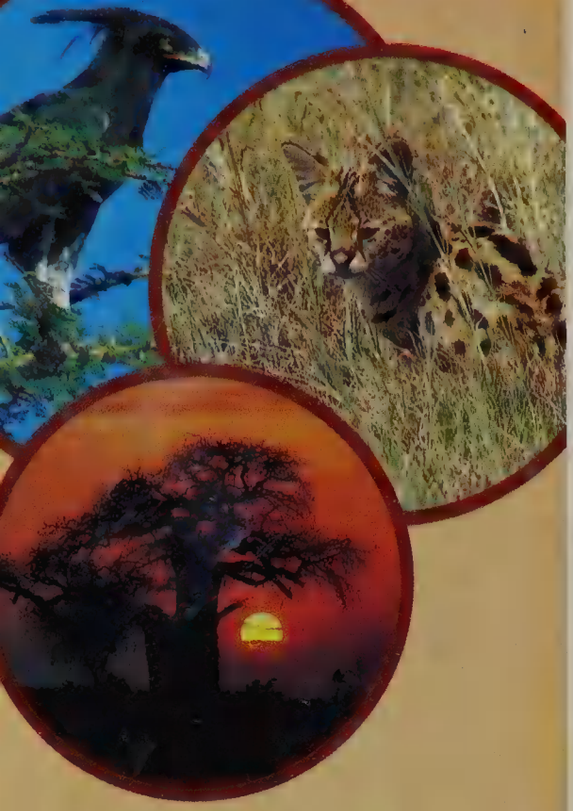

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For the next six weeks we explored a 300-mile section of the Irrawaddy River, collecting fossils along its banks and terraces. This fieldwork was rewarding, but we yearned to visit the Ponnyadaung Hills, a mere 200 miles to the west. To impress upon our Burmese colleagues how eager we were for information about the 40-million-year-old fossil beds, we left our copies of Barnum Brown's field maps and publications with them. They promised to attempt a reconnaissance of the region in the late fall dry season.

Savage and I returned home and awaited further word on our research proposal to the Burmese government and on results from our Burmese collaborators' visit to the Ponnyadaung Hills. We had heard nothing for almost a year when suddenly a small package arrived from Mandalay. It contained plaster casts of jaws and teeth of several Eocene mammals, one of which was a nicely preserved jaw of *Pondaungia*. U Ba Maw and U Thaw Tint had not only found Brown's localities; they had also succeeded in recovering a new fossil primate. An accompanying letter stated that they had found many more fossil mammal specimens, several of which they thought could also be primates. They encouraged us to return to Burma as soon as possible to visit the localities and to work with them on publication of the finds. In December 1978, arrangements were made, and we departed once again for Burma.

On our approach into Mingaladon Airport in Rangoon we were asked to set our watches back thirty minutes in accordance with Burma Standard Time. The British businessman sitting next to me intoned, "Set your watch back thirty minutes and turn time back thirty years." Indeed, little has changed in Burma since its independence in 1948. But our minds were set on a much longer time frame, for

Stephen Nash

This drawing of Amphipithecus *is based on fossil evidence and an interpretation of the order of evolution of anatomical features found in living higher primates.*

Russell L. Ciochon

Our knowledge of Amphipithecus *comes from fragments of two separate jaws. One portion (left) was found in 1923, another (shown overlapping) in 1977.*

we were hoping to turn time back 40 million years!

After several days of preliminaries, we made the short hop by air to Mandalay and prepared for our journey to the Ponnyadaung Hills. U Ba Maw and U Thaw Tint could not accompany us on this trip since they were in the middle of university exams, but they sent some of their students with us. Before dawn on December 20, our small caravan—two World War II–vintage jeeps loaded with camping and excavation equipment, four geology students, a cook, a mechanic, two drivers, Tin, Savage, and myself—left for the field.

To reach the Ponnyadaung Hills we had to cross the two great rivers of Burma. Crossing the Irrawaddy was a simple matter of driving over a steel-girder bridge, but at the Chindwin River our two jeeps had to be loaded onto a flatbed barge along with chickens, goats, bicycles, and a large number of other passengers. A small tug then towed us across the mile-wide river. After several more hours of driving we reached the Pale Township People's Council, where we checked in and picked up an escort of several armed policemen. Our Burmese colleagues had assured us that the only danger in the Ponnyadaung Hills was an unlikely encounter with a Bengal tiger, but for the sake of appearances, we decided to accept the offer of an escort.

On our five-hour climb from Pale into the Ponnyadaung Hills, the road deteriorated rapidly from a graded gravel track into a series of potholes and dust bowls interspersed by washboard. The open scrub brush and farmland near the Chindwin River quickly gave way to gently rolling forested hills. As we climbed still farther, the road became very steep, and the teak and bamboo forest surrounding us came alive with azure butterflies, screeching parakeets, and scampering red-orange jungle fowl. We encountered young Bu

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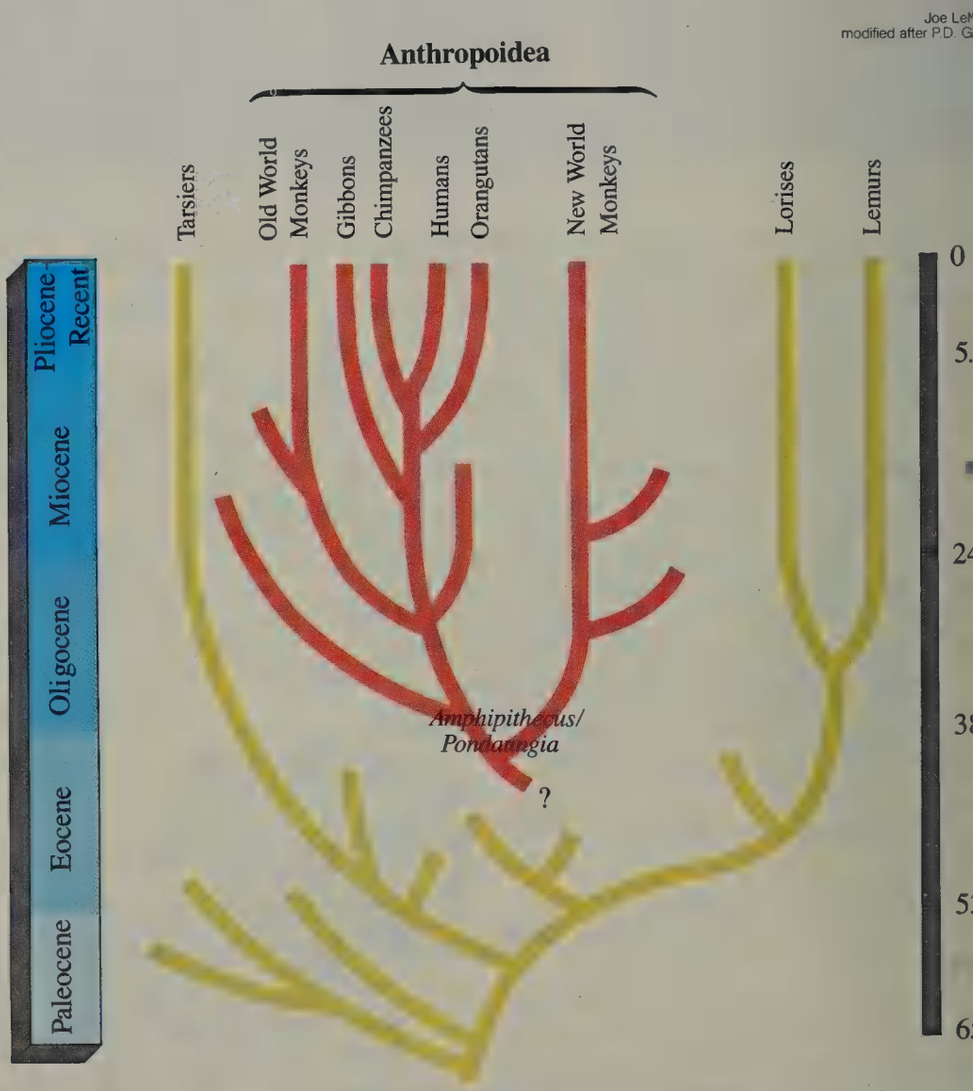
mese men driving oxcarts loaded down with teak logs, but not a single motorized vehicle. At the fifty-five-mile post the road became impassable for even a four-wheel-drive jeep. We transferred our supplies onto two oxcarts, each pulled by two grunting oxen, and began the eight-mile hike down an old cart road into Mogaung village. The oxcart wheels creaked and squeaked—but not as a result of neglect, I was told; rather, the local villagers never grease the wheels because they feel the noise keeps away evil spirits.

Late in the evening of our daylong trek we reached our destination—Mogaung, a village of some nine hundred people. Surrounding the village, which consists of small teak huts raised off the ground on poles, is a bamboo fence. Inside, banana, coconut, and toddy palm trees grow in abundance, and pigs and chickens roam freely. We were led to the hut of U Gyo, the village headman, where we were fed a traditional snack of bananas and green leaf tea. With Tin acting as translato Gyo greeted us graciously and sugge we use the new village schoolhouse base camp. It was rice-planting time, school was not in session. We were hausted, and after a quick meal of chi curry, everyone bedded down.

Early the next morning, with Bar Brown's field map in hand, we proce on foot northwest from Mogaung, thr flooded paddy fields, across s streams, and along well-worn paths ir forest. After we had walked about mile through the lush forest cover, rainbow-banded sediments of the daung Formation suddenly appeared. local villagers called these areas *chaung,* "places without vegetation." ing to the chemical properties of the ments, vegetation, especially fra young rice plants, is not able to gro them. In this case the villager's loss is paleontologist's gain.

Since Barnum Brown had left very



A family tree of the primates lists living groups at the top. The major fossil species some of which left no descendants, are represented vertically by the branching tree. The Anthropoidea, or higher primates, are shown in orange; the Prosimii, or lower primates, which comprise all other primates, form a less unified group (yellow). Some early prosimians, perhaps a group related to lemurs and lorises, gave rise to Anthropoidea. Amphipithecus *and* Pondaungia *are transitional forms that posses a number of anthropoid features but also retain a few prosimian characteristics.*

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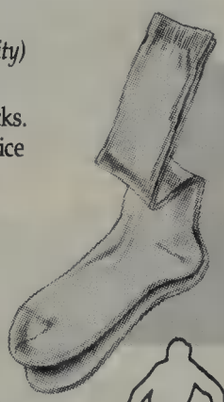

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cise field notes, we had no trouble finding his localities, and we soon began to accumulate a treasure trove of fossils. The Burmese geology students also showed us the spot where the new primate jaw had been found. Over the next couple of days, Savage and I collected the remains of many extinct animals, including hippo- and piglike anthracotheres, rhinolike brontotheres, small deerlike artiodactyls, rodents, lizards, turtles, fishes, and crocodiles. From studies of this fauna and some associated plant remains, together with an understanding of the type of rocks in which they occur, we can reconstruct the paleoenvironment of this part of Burma in the late Eocene. The sediments were deposited by a medium-size river that drained seaward toward the Burmese Gulf, which in the past was located much farther north. Along the banks of this river, which was partially covered by a forest canopy, anthracotheres, brontotheres, and small artiodactyls came to drink. Turtles, crocodiles, and fish swam in the river. In the trees above, the ancestors of the higher primates romped.

On our second night in Mogaung village, the headman, U Gyo, honored us with a visit to "get better acquainted." As spiritual leader and chief administrator of Mogaung, U Gyo had considerable power, but being sixty-five years of age, he had learned to use his position wisely. He spoke of how Mogaung village had changed over the past half century ("actually, very little"). I then asked him when Mogaung had last been visited by Westerners, "people like ourselves." U Gyo thought a while and then began to recount the following story:

When I was a young boy of ten, I remember a white man and woman coming on horseback with several oxcarts of supplies. With the help of Mogaung villagers, they set camp only a few hundred yards from wh we are sitting. The man would ride off ea morning and return late in the evening w his horse packed with odd-shaped roc The woman, who wore pants but was str ingly beautiful, would stay in camp a play with a small dog, whose hair she w constantly combing.

We immediately realized that U Gyo w describing Barnum and Lilian Brown later showed him a photograph of Bro taken in Burma in 1923, and he confirm the identification.

After several more days of fossil hu ing around Mogaung village, we decid to hike to a locality Brown had discover some six miles to the northeast, near t village of Gyat. We found some excelle exposures near a large lotus pond, whi we could recognize from a photograph Brown published in *Natural History* 1925. Unfortunately, we were not able find any fossils. In the late afternoon trekked back to Mogaung, where our co was preparing a special holiday meal roast chicken and potatoes. It was Chri mas Eve. Savage and I rested and sippe clear, sweet alcoholic drink distilled fr the fruit of the toddy palm tree. As the s sank behind the mountains, the air b came chilled, bringing out the smell of t teakwood smoke and frying oil.

As darkness fell we heard a commoti in the distance. One of our police guar who had not returned with the field par burst into camp brandishing his weap proudly. He led a procession of village two of whom shouldered a rough-hew pole carrying a small deer. The deer w immediately butchered and some pa roasted that night. The following day proceeded to our next camp, at near Legan village. There, the deer meat p

Russell L. Cio

Outcrops of the 40-million-year-old Pondaung Formation are bare of vegetation.

ded a magnificent Christmas Day feast
r our entire field party and all the village
ders.

After another week of fossil hunting, we
urneyed back to Mandalay, where more
xcitement was in store for us. At the
Iandalay Arts and Sciences University
e met with U Ba Maw and U Thaw Tint,
ho produced a box of small fossil jaws
ey had collected in the Ponnyadaung
ills. They weren't sure what the six
ieces were, but they had an idea they
ight be primates. Savage and I were al-
ost breathless as each jaw was removed
om the box. The first was a primate, the
iginal of the cast they had previously
nt us. Three of the others also proved to
e early anthropoids. U Ba Maw and U
haw Tint had tripled the early anthro-
id sample of Burma. Of the four pri-
ate jaws they had discovered, two were
ondaungia and one was *Amphipithecus*.
he fourth may represent a type of pri-
ate previously unknown to science. Our
rmese colleagues asked us to help them
blish these finds in Western journals.

After returning to the United States,
avage and I began to study the casts and
otographs of the new Ponnyadaung fos-
ls, making comparisons with Brown's
mphipithecus jaw and Cotter's *Pon-*
aungia specimens. Since several of the
w specimens are more complete than
e older fossils, the characteristics of the
o species are becoming clearer. Both
ssil forms exhibit a combination of lower
d higher primate features, with the lat-
r considerably more predominant, indi-
ting that they were at or across the evo-
tionary transition from prosimian to
thropoid.

Some of the lines of evidence that point
this conclusion can be illustrated by a
ok at *Amphipithecus*, the better known
the two species. For one thing, this gib-
n-size animal, probably weighing about
enty pounds, was relatively large in
mparison to most lower primates alive
the Eocene or even today. The lower
w is deep (top to bottom), both abso-
tely and in relation to the height of the
eth, and this depth extends the full
ngth of the jaw. In the lower primates,
e jaw is not as deep and lessens in height
ward the front. The *Amphipithecus* jaw
also very robust (thick). These jaw
aracteristics relate to the fact that the
ght and left halves of the lower jaw were
sed, unlike those of nearly all extinct
d living prosimians, whose jaws move
dependently as they chew. The fused
ws of anthropoids, which evolved for
ewing tougher foods, are strengthened
d reinforced to withstand the extra
esses that are placed on them during

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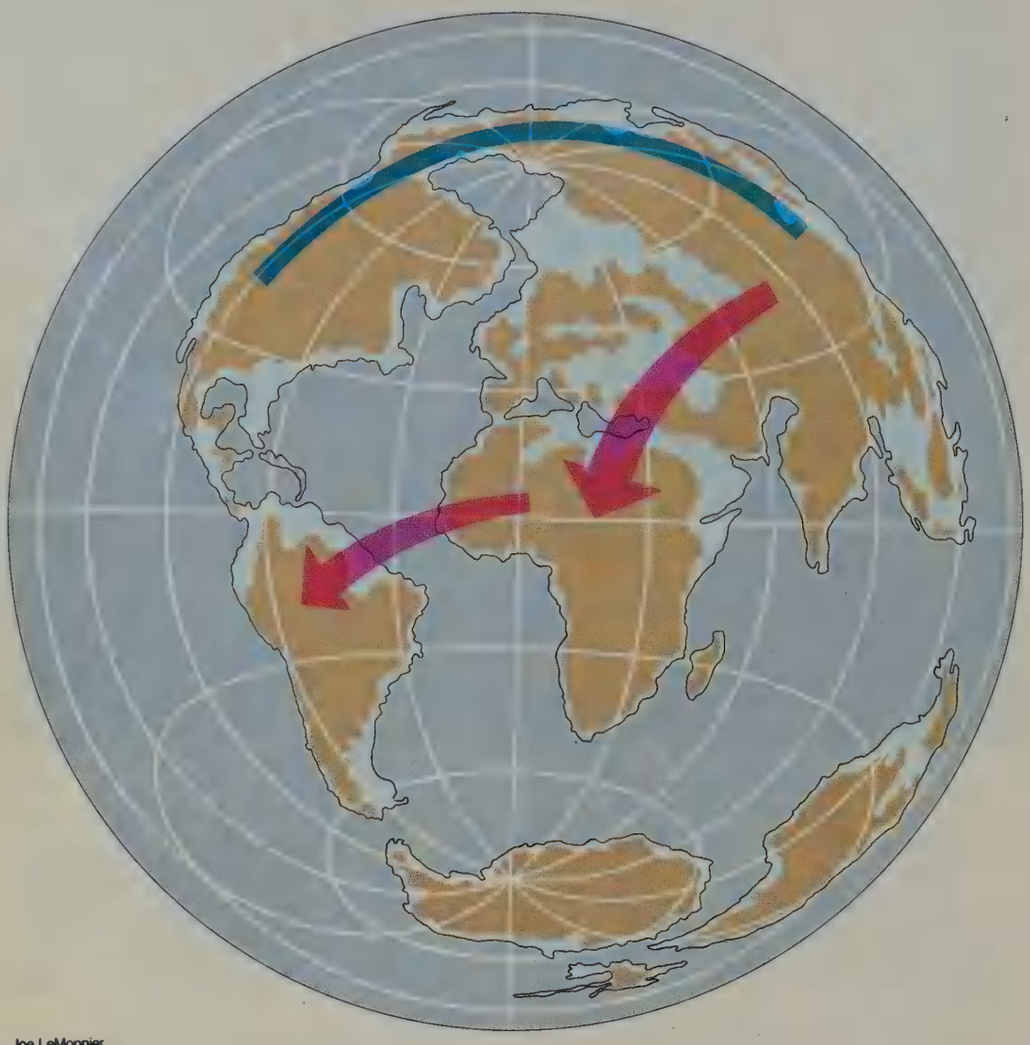
Migration of the Early Anthropoids



Joe LeMonnier

The relative positions of continents, oceans, and shallow seas 40 million years ago are reconstructed in a map of the earth's surface. Before higher primates (anthropoids) evolved, lower primates were present in Europe, Asia, North America, and probably Africa. The Burma fossil finds suggest that the higher primates arose from lower primates in Asia. Early forms probably then spread to Africa and, by way of volcanic islands, to South America (red arrows). Those in Africa subsequently gave rise to all the Old World monkeys, apes, and humans, while the New World monkeys evolved on their own in South America. Another possibility (indicated by the blue band) is that a population of early higher primates came to occupy parts of both Asia and North America, which were connected by a land bridge. When this connection was severed, the New World and Old World groups began to evolve independently, the New World group eventually migrating to South America. No one has discovered fossils of higher primates in North America to support this second hypothesis.

mastication. As in all anthropoids, the jaws of *Amphipithecus* are buttressed where they join by two horizontal, shelf-like thickenings of bone, called tori. (In contrast, the minority of Eocene lower primates that have fused jaws exhibit only one torus, suggesting they are unrelated to *Amphipithecus*.)

The cusps, or elevations, on the chewing surfaces of the teeth are relatively flat, a trend found in fruit eaters. Most prosimian teeth, instead, have a very crested cutting surface, useful for a diet of insects or leaves. In this respect, *Amphipithecus* resembles 30- to 35-million-year-old anthropoids found in Egypt's Fayum province (see "Dawn Ape of the Fayum," by Elwyn L. Simons, *Natural History*, May 1984). Another important consideration is the number of teeth in the jaw. Among primates in general, there is a long evolutionary trend toward reduction in the number of teeth. *Amphipithecus* has three premolars, a relatively primitive feature it shares with some prosimians and New World monkeys. Old World monkeys (as well as apes and humans) have two premolars. In this respect, *Amphipithecus* (or some closely allied species) is a suitable candidate as a forerunner of both the New World and Old World anthropoids—in other words, of all higher primates.

The original specimen of the *Amph pithecus* lower jaw contained the root the canine tooth, the root of the first pr molar, the second and third premolar and the first molar. Luckily, the new spe imen has helped complete the pictur since it contains the first and second m lars and part of the third. The squa shape of the second molar (viewed fro above) is significant, because this characteristic of anthropoids. In contras among the lower primates there is a na rowing toward the front of this tooth. Th newly discovered first molar has resolve a rather arcane controversy over the poss ble position of a rearward cusp known the hypoconulid. A nick in the origin specimen, where some believed this cus had broken off, was not in the positio characteristic of higher primates. As turns out, the new specimen shows there no hypoconulid cusp at all on the first an second molars. In this feature, *Amph pithecus* differs from all Old World a thropoids but resembles many Ne World monkeys.

The fossil finds from Burma sugge that the first higher primates evolved Asia some 40 to 45 million years ago an spread from there to the other parts of th world. This geographic spread could hav occurred by way of a number of route but I believe that the most likely sequenc was the following one. At the end of th Eocene, early anthropoids, the Ponny daung primates or their close relatives, m grated across Asia into Africa by crossin the narrow, swamplike Tethys Sea, whic then separated the two continents. Once Africa, these early higher primates contin ued to evolve, with some populations b coming ancestors of the 30- to 35-millio year-old Fayum primates of Egypt (an ultimately of all Old World monkey apes, and humans). Other populatio crossed the then-narrow equatorial Atla tic Ocean by island hopping along a seri of volcanic islands. In this way the reached South America and became th ancestors of the New World monkeys.

The increasing clarity with which Wes ern paleontologists are now able to vie these events in primate evolution is owe in large part to the discoveries made b our Burmese colleagues, who continue search for more fossil evidence. Althoug I have returned to Burma several tim since my memorable visit to Mogaung v lage, I have not been granted furth opportunity to visit the Ponnyadau Hills. While a field trip to southern Chi was arranged in 1983, and one to Vietna is planned for next year (both countri have related geological deposits), the roa to Mandalay still beckons.

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Barbados Odyssey

Many emigrants fulfill their dreams by returning home

by George Gmelch

In 1968, Wayne Beckles, age twenty, single, and without prospects of a steady job, emigrated from his native Barbados to the United States, to live in New York City's borough of Brooklyn. Over the next nine years he held various manual jobs—handyman in a family grocery story, machine operator, deliveryman—while attending night classes at the City University of New York. After receiving his B.A. degree, he was hired as an accountant by a small firm in Queens. He married Norma Cumberbatch, a Barbadian emigrant, and they started a family.

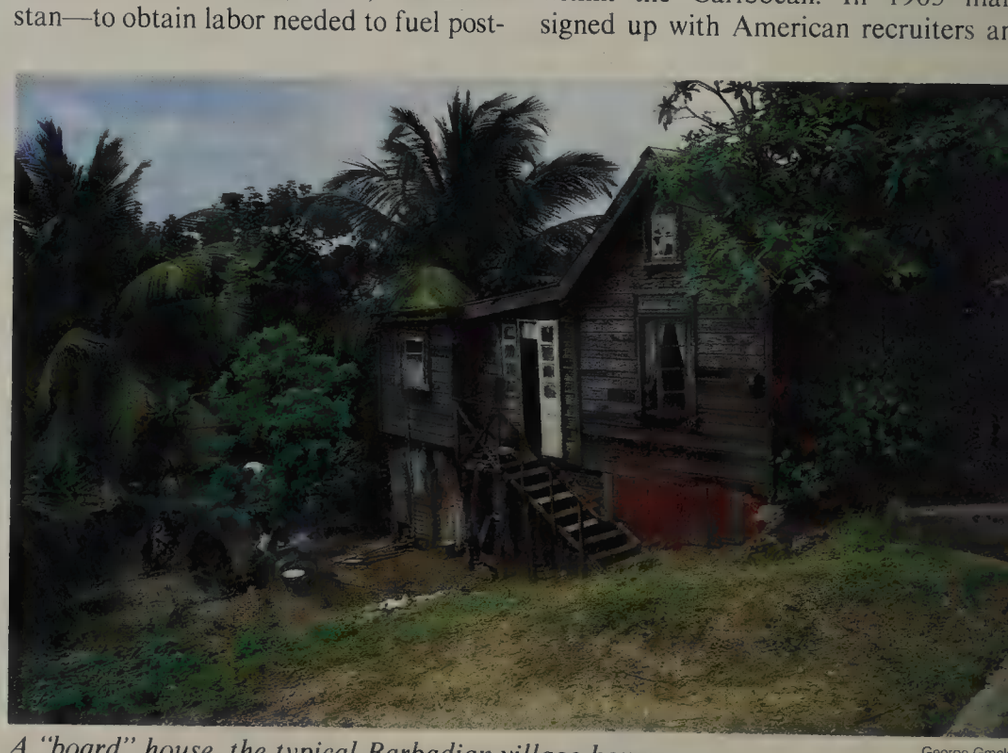
On a visit to Barbados during Christmas 1980, the couple started to talk seriously about going home. Norma didn't want to raise her children in urban America, and Wayne missed the Caribbean climate and outdoor living. So he began to apply for jobs advertised in *The Advocate*, a Barbadian newspaper that circulated among his emigrant friends. Eventually he landed a job as accountant for a sugar company. "I agonized over the decision," he said. "The salary was only half what I was making in the U.S., but my wife insisted that what mattered was which country we wanted to rear our children in." In 1982, Wayne Beckles, with a profession, savings, and fourteen years experience in a metropolitan society, took his family home to the West Indies.

The Beckleses are among tens of thousands of emigrants who in recent years have returned to their native lands. During the past decade there has been a counterstream of migrants returning from Britain and North American to many parts of the Caribbean, including Puerto Rico, Jamaica, and Trinidad, as well as Barbados and several smaller islands. One survey found that 13 percent of all Barbadian men, and half as many women, have lived abroad for more than a year, mostly in Britain or the United States. The actual number of emigrants returning for good each year to countries like Barbados can only be estimated because, as they pass through airport customs and immigration, they are indistinguishable from those returning solely to visit. But there is ample evidence from other sources—the transfer of foreign bank deposits, construction of new housing in rural areas, and population increases beyond natural growth—that return migration is rising sharply in much of the Caribbean.

The phenomenon is not unique to the West Indies. Southern Europe, particularly Spain, Portugal, Italy; and Turkey, has also seen the tide turn. The 1973–74 recession in Europe, induced by the oil embargo, contracted the northern European labor market, slowing emigration from the south to a trickle and causing many emigrant workers to go home. Some went of their own accord; others were encouraged to go home with cash incentives from governments that no longer needed their labor. The European economies have since rebounded, at least partly, but the return flow has not abated. The Portuguese government, for example, estimates that 30,000, or about 6 percent, of its 500,000 expatriates are returning home each year.

Barbadian emigrants left the island as part of a mass migration from the English-speaking Caribbean to Britain and North America following World War II. Most sought jobs; some went to attend university. In the 1950s Britain began actively recruiting workers from its former colonies—the West Indies, India, and Pakistan—to obtain labor needed to fuel post-war reconstruction and a booming ec omy. The London Transport Agency, example, opened an office in Bridgeto the capital of Barbados, to recruit bus c ductors and ticket collectors. In the m 1960s, the destination of Barbadian e grants shifted to North America. Britain, competition in the workplace a hostility and resentment toward "colore immigrants led to the passage in 1962 the Commonwealth Immigration A which restricted further emigration. the late 1960s, the flow of emigrants fr the West Indies to the United Kingdo had virtually ended. At about the sa time, however, the United States a Canada opened their doors. Altogeth between 1951 and 1970, 14 percent Barbados' population of 230,000 left t island.

This was not the first time Barbadia had emigrated from their island. Ev since the 1830s, when slavery was ab ished throughout the English-speaki Caribbean, migration has been comm and widespread. On Barbados and oth islands with similarly dense populatio and scarce resources, emigration is a ne essary safety valve. In the nineteenth ce tury, Barbadians went to larger islan within the Caribbean. In 1905 ma signed up with American recruiters a



A "board" house, the typical Barbadian village home

George Gmel

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emigrated to Panama to dig the canal. According to geographer Bonham Richardson, by the time the canal was completed in 1914, approximately one-quarter of all Barbadians had traveled to Panama. In the 1920s, Barbadians emigrated to Curaçao, Trinidad, and Venezuela to work in the newly developing oil fields. Others went to Cuba to work in the sugar industry. And even before World War II, a small number had emigrated to England—the "mother country"—and to North America. But the flow to these "metropolitan" countries, as they are referred to in the Caribbean, was only a trickle compared with the torrent that followed after the war.

After working abroad for anywhere from one to thirty years (the average was twelve years among the 135 emigrants interviewed for my study), Barbadians are returning home. A few are pushed home by unfavorable conditions abroad—unemployment, racial tension, and personal problems. The British economy has been recovering slowly from the last recession (1979–82), and what gains have been made have done little for West Indians. The unemployment rate among West Indians in British cities is triple that of whites. Jobs for young West Indians are so scarce that, in an ironic reversal of their own parents' emigration, some who were born and raised in England are now leaving to seek their fortune in the Caribbean.

West Indians have been disturbed by new signs of racism in Britain, such as the rising popularity of extreme right-wing groups like the National Front. The rhetoric and policies of Margaret Thatcher's conservative administration have also contributed to the West Indians' growing uneasiness. Some right-wing members of Parliament have recently proposed that the government encourage West Indians to go home by offering them money. One forty-year-old returnee said that the final straw for him was the British Nationality Act of 1981, which determined that children born in Britain of West Indian parents would no longer qualify for British citizenship. "The notion that my children," he said, "would not be citizens of the country that I had given the best years of my life to was a slap in the face."

Some return migration is precipitated by a personal crisis: breakup of a marriage, death of a spouse, trouble with children, ill health. A hotel maid in an English resort town, who returned after being divorced, told me, "After my husband left, it was just me and kids in the house, and that's not good for anybody. I was lonely and bored. We needed more relatives around." An engineer in the London Post Office returned when his wife developed severe allergies; a construction worker in Toronto came home after suffering a stroke; and a mechanic in Brooklyn brought his family back when his mother in Barbados, was diagnosed as having cancer. In Britain, doctors often advise West Indians with serious health problems, especially mental disorders, to reemigrate. The change of scene and climate may be good for the patient, but it also helps to reduce the burden on the National Health Service.

While some emigrants go home because they are unhappy with their lives abroad, the vast majority return because of their attachments to Barbados and its people. One elderly man, chewing a stick of sugar cane as he spoke, told me, "The money was good [in Canada], and the people treated me with fairness. But in the end I wanted to be home with my own people, in my own land." Many emigrants want to be near aging parents and old friends again. Others have patriotic reasons. A woman who graduated from Colgate University and worked as a housing research analyst in Washington, D.C.

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eturned to Barbados to teach high school. "Barbados is a developing country," she aid, "and I felt that any contribution that make in my lifetime, I want to make ere." Emigrants also miss the warm, unny Caribbean climate. Returnees I interviewed frequently complained about he long, cold, dark winters of the northern ities where they had settled—New York, oronto, Montreal, London, Birmingham.

For many emigrants, return migration s best understood as merely the fulfillment of what they had always intended to o, the natural completion of the migration cycle. At the time of their initial emigration, most Barbadians only plan to be away long enough to save money to buy a ouse and perhaps a car or to acquire a ollege degree or a trade. Despite such intentions, however, only one of every four migrants from Barbados ever manages to eturn home for good. Some simply cannot afford the passage or plane ticket back o Barbados. In any case, those who fare oorly overseas are disinclined to return ecause they will lose face—all emigrants re expected to come home with at least nough money to buy a home of their own. nd unless they are receiving a pension, ost migrants will not return home without good prospects of a job. Because Barados has scarcely any benefits for the unmployed, they are better off staying broad. Conversely, the very successful lso seldom return. To do so would mean iving up well-salaried positions and a tandard of living that cannot be equaled n Barbados. It can also mean costly obgations to share the wealth with less-well-ff kinsmen at home.

Are those who return merely adding to he island's overcrowding (with 1,480 peole per square mile, Barbados is one of the ost densely populated nations on earth) r do they contribute to development? Many who have studied the impact of reurn migration on villages of the Third Vorld have argued that returnees seldom ring back work skills that are useful in he homeland; play a minimal role, at best, introducing modern ideas; and rarely invest their overseas savings in new enterrises that create jobs or benefit the reion. But most of these conclusions have een drawn from research conducted in ural areas, where the focus has been on easant or worker migrants. College-eduated and technically trained migrants ettle in towns and cities, where they seek he kinds of white-collar jobs they had broad. This group of return emigrants ay play a different role.

Barbadian emigrants do bring home ew attitudes and ideas. Even Barbadians ho have never been away concede that

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Ellen Frankenstein

Young Barbadian men at a village rum shop

returnees are more "broadminded" and experienced than people who have never emigrated. They generally have a heightened sense of justice, stand for better treatment of women, are less tolerant of racism, and have a more developed sense of West Indian nationalism. They are also said to be more willing to support unpopular causes. Many Barbadians also believe that returnees are more ambitious, harder working, and more goal oriented.

But it is difficult to prove that returnees' attitudes rub off on their neighbors. Barbados is a conservative society where people are slow to accept change, especially "foreign" ideas brought back by their own countrymen. "When proposing some change to my parishioners," said an Anglican rector, "I have to be very careful not to let them think I learned it in England." One middle-aged civil servant who had returned from London talked about his superiors who had never been away: "Because you've been away and maybe know more about something, they feel threatened. They don't want to admit that you have the answer, especially when you've been on the job half as long as them." Another man said of emigrants:

> They have the same ideas as the North Americans who live here. The difference is that local people will listen to what the foreigner has to say, but not to their own kind. They'll say, "Who is he to tell us what to do, he's only a Barbadian like us!"

As a general rule, material items are more easily transferred than ideas from one culture to another. In an earlier period, Barbadians returning from work on the Panama Canal with what local Barbadians referred to as "Panama money" introduced window screens and improved sanitation. But today's returnees are introducing little in the way of new items—other than their curious use in a tropical climate of wallpaper and wall-to-wall carpeting, neither of which has been imitated by other Barbadians. As a group, however, the returnees who have become accustomed to new technology abroad are themselves quicker to accept new ideas and goods when they appear in Barbados.

One problem with assessing the influence of returnees in the larger community is trying to disentangle their role as agents of culture change from all the other external influences on Barbadian society. Barbadians today have so much contact with the outside world through films, foreign television programs, tourism (the number of foreigners visiting the island each yea exceeds the population), and travel tha there is little that migrants can introduc that the locals have not already seen.

But return emigrants do have an impac in another way. After years of hard work most emigrants arrive home with a sizable amount of capital, from savings and from the sale of overseas assets, such as a house a car, and furniture. To save money, many emigrants set aside a fixed percentage o their weekly paychecks to be deposited in a savings account or sent home to Barbados for safekeeping. Blue-collar emigrants often set up small, informal credit associations, known as a partner or meeting, in which each of a dozen or so members contributes about $8 to $10 per week. Periodically, each member gets a lump sum. Emigrants say it is difficult to save small amounts of cash, whereas the lump payment is large enough to put away.

Most returnees use their savings to purchase a house. Those who already own homes add a room or buy new furnishings and appliances. Those who can afford it also buy a car, an important status symbol among middle-class Barbadians, who shun public transportation. This display of wealth, where locals remember the emigrant's humble backgrounds, sometimes causes jealousy and friction. Granville Hunt, for example, resettled his family in his boyhood village on the Atlantic side of the island, an area still untouched by tourist development. With their overseas savings, the Hunts refurbished the family rum shop, which had stood vacant during their absence, and bought a house overlooking the Pentacostal Church. Unlike most houses in the village, which are built of wood and have corrugated iron roofs, the Hunts' house is masonry with a til

George Gmel

A "wall" house under construction for a return emigrant from Liverpool, England

NE

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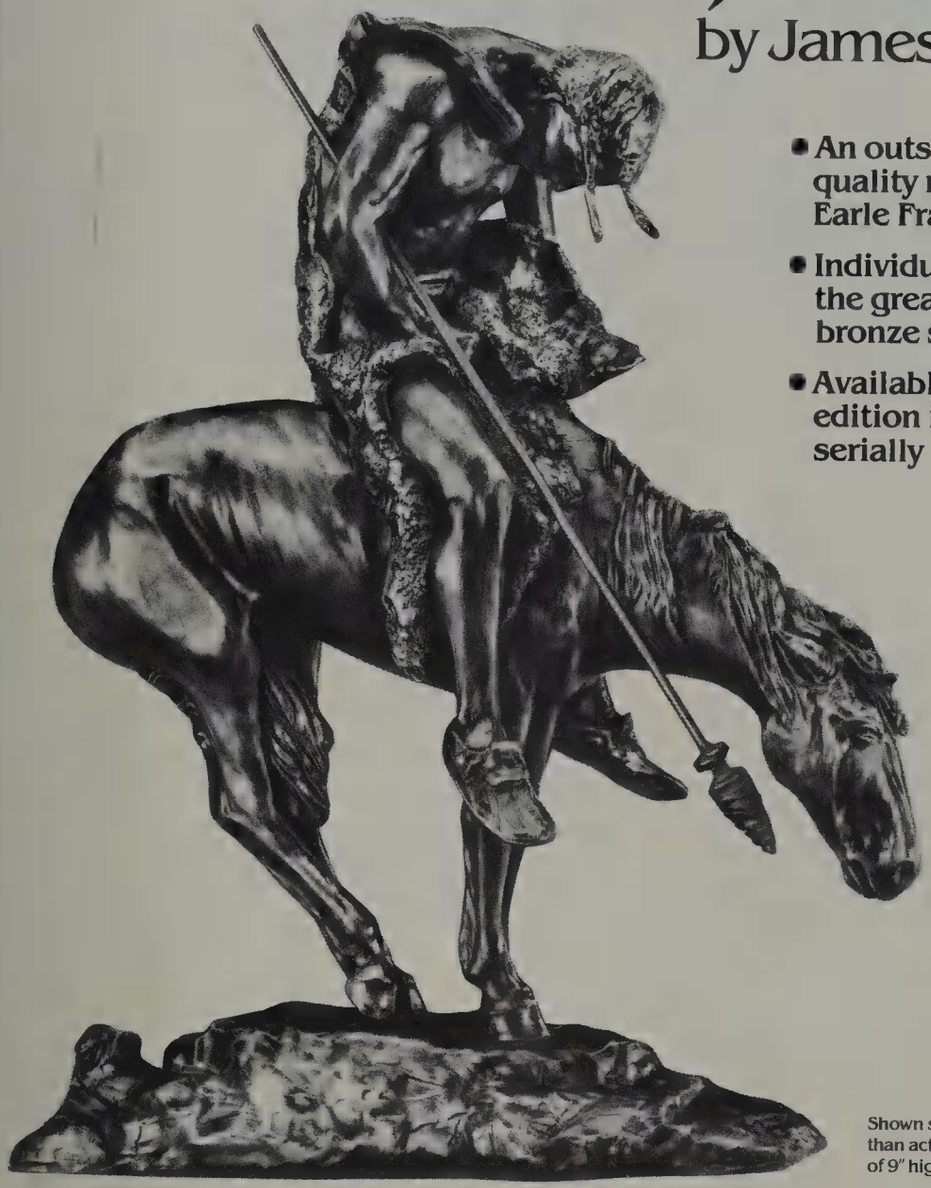
by James Earle Fraser



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George Gmelch

In Barbados, once a slave colony, houses represent freedom, security, and high status

roof. It is twice the size of the other homes in the village and equipped with modern kitchen appliances and a stereo. Painted cornflower blue, it stands on the hillside like a beacon, beaming to one and all the Hunts' success as emigrants. The family's Oldsmobile, which dwarfs local vehicles and is more than half the width of most village streets, is also a reminder that the Hunts have made it.

The Hunts' ostentatious return has brought them trouble. Relatives and friends who had always been friendly during vacation visits are now jealous. Village gossip has it that the Oldsmobile and house are the result not of hard work and saving but of winning a lottery. Villagers rarely come to the rum shop, lest they add to the family's weath. "Even the people from our church don't shop here," said Mrs. Hunt.

> They don't want us to have their business. You can't win. If you come back with money, they are jealous. If you come back with nothing, they ridicule you. . . . When I was a poor shopkeeper [before emigration], we had more friends than we have today. You see, then we were all at the same level.

Some anthropologists argue that it would be better if emigrants like the Hunts invested their savings in enterprises that create new jobs and capital in their home societies. In Barbados, however, such criticisms carry little weight. As in all former Caribbean slave colonies, property ownership is associated with freedom, economic security, and high status. The reason most Barbadians go abroad in the first place is to earn enough money to someday buy a home of their own. And it is through home ownership that returning emigrants communicate to friends and neighbors that they have been successful. This is largely the reason emigrants usually purchase or build "wall," or masonry, houses, rather than the lower-status "board" houses that resemble those they were raised in.

Only one in seven Barbadian returnees invests his savings in a business. A 45-year-old migrant, for example, spent $16,000 he had saved during five years in Montreal to set up an auto body repair shop. Another returnee opened a typewriter repair shop. Still another man had a fishing boat built with money earned on an assembly line in England; he now employs several men to work it for him. Other migrants who brought cars home from abroad are now taxi drivers. Although the businesses the returnees have established do provide needed services and contribute to the smooth running of the economy, they generally are not novel enterprises and do not employ many people.

But many emigrants have returned to take professional and highly skilled jobs in the workplace, benefiting their society in important ways. Most emigrants return to Barbados with a higher level of work skills and training than they had before they left. One third of those in my sample had gone to college while abroad and nearly as many others received on-the-job technical training. Fifty-five of the migrants interviewed (about 40 percent) work at professional or technical jobs in Barbados, whereas only 9 percent of the total Barbadian population fall into this job category. And while 31 percent of the island's population work at unskilled jobs in manufacturing, only one percent of returnees do. The president of a Bridgetown computer firm said, with some exaggeration, "There's nobody in business in Barbados who is moving up, who has not been away." Barbados' past three prime mini ters, more than half the current membe of its parliament, and most of the profe sors at the island's University of the We Indies campus are return emigrants.

Those who have had the most impa have been professionals and manage with the authority and freedom to put in practice the ideas and techniques the learned abroad. The others, the worke on the shop floor rather than the bosses the front office, usually lack the power change things. A diesel mechanic traine in England and now employed in one Barbados' six sugar factories, for exar ple, found that he knew much more abo his job than his workmates but noneth less had little effect. His fellow worke were not interested, he said.

> If you tell them something new, they thi you're trying to fool them. The guys he don't wear protective clothing when they' welding, and the factory won't make the until there is a serious accident. I've tried show some of them that they should do the right way, to look after themselves they'll get injured. Some listen, but mo don't.

In short, the impact of the blue-coll returnee to Barbados is like that of retur ees in rural areas in other parts of t world. But white-collar, college-educat returnees have made numerous innov tions in their jobs, generally in the areas computers, medicine, and engineering, f which no graduate training is offered Barbados. An American-trained accou tant, now the head of the accounting d partment in a Bridgetown firm, intr duced electronic processing of the firm accounts, following the model he h learned in New York. Another accounta introduced a new audit procedure he h learned while working in London. Follo ing his return from Montreal, an obstet cian introduced new techniques for mo toring babies before birth. A rector w returned from England to assume the s nior position in one of Barbados' elev parishes instituted new policies to increa the participation of parishioners in chur services. A movement to deinstitution ize child care in Barbados came from in viduals in the Ministry of Social Servic Board of Child Care who had become f miliar with a new approach while worki in Canada. In these and other ways, retu migrants have shared their gains abro with their fellow Barbadians.

George Gmelch is an associate profess of anthropology at Union College, Sch nectady, New York. He has also done r search on return migration in Newfoun land and Ireland.

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Wild radish lacks the swollen root of its cultivated relative but, like many weeds, produces showy wildflowers.
Frank S. Balthis; Nature's Image

Radishes Go Wild

The country cousin of the garden radish is a weed with a difference

by Norman C. Ellstrand

You see one weed, you've seen them all. Or have you? At first glance, every dandelion in a lot, every clump of crab grass in your yard, looks pretty much like the next. Some plants may be a little bigger or have a few more leaves, but these superficial size differences, due to the vagaries of the plant's environment, are about the only major variations apparent among members of a local weed population. The basic and dramatic differences of genetic origin, while well known between separate weed populations, for example, those a few miles apart, are not expected among weeds of the same species growing in the same field.

Ecologists have long accepted this pattern of nonvariability. The quick growth, quick demise weedy life style affords separate plant populations little opportunity to exchange seeds and thereby acquire genetic diversity. The black mustard in the empty lot across the street may be descended from only one or just a few seeds. And only a few seeds from that population may go on to start a colony in the next lot. It's like planting your garden with multicolored zinnias and giving your neighbors only a few seeds produced by your plants to start their own garden. Even if you started with a good deal of variety, your neighbors would end up with one or two predominant colors. And if they gave *their* neighbors seeds in a similar fashion, almost all of the yards would have a uniform hand in only one or two generations. Thus, even for those of us who love them, weeds, as a rule, can be monotonous.

But wild radish flagrantly breaks the rules. Like confetti blown in from a New Year's Eve party, the multicolored flowers of wild radish—pink, white, yellow, purple, bronze, brick—deck the vacant lots and fallow fields of California each spring. Close inspection reveals that, beyond color, petals differ in shape, vein color, and even angle of spread. Leaf shape and hairiness, as well as the texture, shape, and color of the multiseeded pods, may vary. These differences are genetically, rather than environmentally, based. That is, the differences are coded in the genes, not coaxed out by the plant's immediate surroundings. With all of their variety, individual plants in a wild radish population can be distinguished almost as easily as faces in a room. The presence of such abounding diversity is as surprising to plant ecologists as finding Easter eggs in a carton marked Grade A, Large White.

Why, and how, do wild radishes break the rules, and how do our assumptions about uniformity of weed populations hold up in light of this evidence? The thrust of my research has been to answer these two questions by asking two more: how much genetic information can be borne by the seeds within the radish fruit, and how likely are gene-bearing pollen and seeds to be transported from one weed population to another? Although both of these factors—genetic information within fruits and long-distance mating—can create variation, neither had been measured directly in any natural plant species.

The seeds of most weed plants are dispersed individually in single-seeded fruits, from the grains of grass stuck in your socks to the plumes blown off a dandelion head. But in wild radishes, the fruit—a tear-shaped, thick, styrofoamlike pod that never opens, called a loment—generally bears from two to eight seeds. Since the fruit is the vehicle for founding a population, radishes will always start with more individuals per vehicle than the typical weedy species.

But the amount of genetic information in each fruit depends on both the number of seeds in the fruit and the number of parents contributing to those seeds. All the seeds share the same mother, but they may have different fathers. A radish fruit containing eight seeds can carry the offspring of as many as nine parents (the mother plus a different father for each seed) or as few as two (the mother plus a single father). The effects of single versus multiple paternity can be compared by considering the analogy of giving zinnia seeds to your neighbors. If you gave each neighbor half a dozen seeds from a single plant, all of the neighbors' resultant plants are more likely to have the same flower color than if you gave them one seed each from six different plants. In the same way, if a radish fruit bears the seeds sired by a single father, each fruit founding a new population some distance away will represent a fairly narrow array of genes, not very different from other weeds with their single-seeded fruits. But if the seeds are sired by several fathers, then each "colonization" will involve genetic information from several individuals.

Can we expect radish pods to pack an assortment of genes? Until recently, virtually nothing was known about the paternity of seeds within the multiseeded fruits of any plant species, but zoology and pollination ecology offered some clues. The number of fathers contributing to the seeds of a fruit is biologically analogous to the number contributing to the offspring in the brood of an animal species. Multiple paternity is now known to exist in a wide array of animals from sowbugs to lobsters, fruit flies to spiders, snails to squirrels. Futhermore, pollination ecologists have discovered that pollinators frequently carry pollen from a number of plants, rather than unloading all of one plant's pollen onto another. Both observations suggest that multiple paternity could be common in plants.

A painted lady butterfly alights on a wild radish blossom. Such flying pollinators may be carrying pollen from distant, as well as nearby, flowers. If pollen grains from different sources are deposited at the same time, the seeds in the resultant radish fruit may have several different "father" plants.

Maureen Stanton

Most weeds show little variety; wild radishes are an exception because no one plant typifies the species. Wild radish flowers blooming in the same field often vary in hue, shape, and even vein color.

Diane L. Marshall

But other studies show that after being deposited on the stigma of the "mother plant," pollen may germinate and produce tubes that grow at different speeds. For example, a bee may deliver a mix of pollen from a variety of sources, but most likely all or most of the seeds of a fruit will share the one father whose pollen tubes grow the fastest.

When my research associate Janet Lee and I asked whether multiple paternity was possible in wild radish, we had no preconceptions. Our goal was to identify the father of each seed within a fruit in order to directly count the number of fathers contributing to that fruit.

We chose to study a small, isolated wild radish population at the University of California's Agricultural Field Station in the Moreno Valley. All of the flowering plants within this radish population were typed for chemical genetic markers called allozymes. The advantage of using chemical allozymes, instead of characteristics such as fruit shape or flower color, is that allozymes are inherited simply, expressed in both parent (flower) and progeny (seed) tissue. Furthermore, this procedure is cheap and efficient. After we harvested the mature fruits, we identified the genotype (genetic makeup) of each of the seeds of several fruits. Because we already knew the mother's genotype, we were able to subtract that from the genotype of the seed. The remaining genotype comprises the father's genetic contribution. We then compared the father's contribution with the genotype of every plant that had flowered in the population because these comprise the possible fathers. Geneticists use the same approach to exclude a possible father (or fathers) in a paternity suit.

In this way, we were able to assign each seed to one or a few possible fathers. When these possibilities were compared for the seeds from a single fruit, multiple paternity was identified in those fruits in which two or more seeds could not have shared the same father.

More than 85 percent of the fruits we tested contained seeds having different fathers. In many cases, three or four fathers contributed to a fruit. A radish fruit that colonizes a new site, landing in a new field, for example, will often contain the genetic information of three or more parents.

My associate Diane Marshall, now of the University of New Mexico, devised a series of experiments to determine how multiple paternity comes about. Marshall and I agreed that multiple paternity could result either from a visit to a flower by a single pollinator bearing a mix of pollen from a number of plants or from repeated

Wild mustard and wild radish belong to the same family and are commonly found together in weedy fields, right. Unlike radish flowers, wild mustard flowers are alway yellow. Below: The wild radish is a hybrid descendant of the cultivated radish and the jointed charlock, closely related plants that were introduced into California in the nineteenth century.

Steve Solum; Bruce Coleman, Inc.

visits by different pollinators to a single flower, each bearing pollen from a different plant. Marshall's experiments revealed that fruits produced from a single pollination involving a mixture of pollen from different father plants very often resulted in one fruit containing seeds with different fathers. But fruits produced by sequential pollinations with pollen from a variety of donors had fewer fathers, even when pollen from a second source was delayed by as little as fifteen minutes. If the delay was more than an hour, there was hardly ever more than one father per fruit. Because the average interval between pollinator visits to a single flower in nature is more than two hours, Marshall concluded that the most likely cause of natural multiple paternity was transport of pollen from different plants by the same pollinator.

The ecological advantage of multiple paternity later became clear. Marshall found that multifathered fruits produced both more and larger seeds than those sired by any single father, even the father producing the largest and most numerous seeds. Maureen Stanton of the University of California at Davis had already shown that large wild radish seeds have a better opportunity to germinate, grow, and reproduce than do small seeds. Frequently produced, multiply sired fruits are therefore likely to be the better at colonizing new fields because they bear the larger seeds.

Long-distance pollen exchange could also foster variety. We can return again to the case of the neighborhood's multicolored zinnias. Each of the neighbors had only one or two colors of zinnias in their gardens, but taken together, the gardens have dozens of colors. If neighbors began a program of exchanging even a few seeds each year, in a few years most of the variation available would be present in every garden. Similarly, pollen exchanged between natural populations could create a blend of diverse wild radish genotypes.

Are wild radishes from different populations likely to mate? The answer depends on the activity of the radish's pollinators. Insects such as butterflies and moths (for example, painted ladies, cabbage butterflies, skippers), bees (honeybees, bumblebees, carpenter bees), syrphid flies, and even the odd beetle pollinate wild radish. The primary insect species responsible for pollinating these weeds can vary over a few miles or a few weeks. And while all of these insects are capable of flying for miles, the frequency of long-distance flights is hard to measure.

Traditionally, pollination ecologists have described mating patterns for insect-pollinated plants by watching insects as they move among mapped plants within a population. Compiling these plant-to-plant moves, ecologists have inferred that the vast majority of mating distances are very short, generally on the order of one to a few yards. Interpopulation matings, then, should be extremely rare, representing far less than one percent of the total seeds produced in any generation. But episodes of these matings are next to impossible to count by following insects, as this would involve simultaneous monitoring of all of the edges of a population for the arrival of pollinators.

The genetic approach to paternity, in contrast, makes for easy identification of those seeds resulting from interpopulation mating. Because the father's genetic contribution can be described directly and compared with all possible local fathers, a contribution that doesn't match any of these must have come from another population. Lee, Marshall, and I studied a di ferent population of wild radishes in eac of three years. The first two populatio were isolated from the next nearest radis by well over half a mile, the third by mo than one hundred yards.

We found the frequency of long-di tance matings to be more than 8 perce for the first two populations and almost 1 percent for the third. Such rates are hig enough to introduce plenty of genetic var ation into a wild radish population withi just a few years.

Why does wild radish break the rule Multiple paternity and long-distanc matings, our two possible sources of th tremendous genetic variation in wild ra ish populations, explain why wild radis stands apart. Other factors, however, ma also be involved. A bank of previously u germinated seeds in the soil may add th genetic "memory" from former popul tions. Also, long-distance migration fruits may take place more often than commonly thought.

You can expect to be hearing mo about the ecology of the wild radish, i cluding how diversity, once achieved, maintained in wild populations. Easy t find, easy to grow, and easy to manipulat wild radish is an ideal research plant tha still retains some secrets.

Whales That Go to Extremes

North Pacific humpback whales bang heads on the mating ground, but when they get to the feeding ground, they put their heads together

by C. Scott Baker and Louis M. Herman

Often portrayed as a gentle giant, wooing its mate with a song, or as a solitary nomad, wandering the oceans in search of food, the humpback whale is proving to be neither. Instead, we are finding that these leviathans are, by turns, more contentious and more cooperative than we ever imagined them to be.

Humpback whales are a cosmopolitan species, with major populations in the Pacific, the Atlantic, and the oceans of the Southern Hemisphere. Like most baleen (filter-feeding) whales, they migrate between summer feeding grounds in near-polar waters and winter breeding grounds in warm equatorial waters. Nearly 6,000 miles round trip, this annual migration is one of the longest made by any mammal. The thousands of humpback carcasses studied by biologists over the years have provided evidence that the species reproduces seasonally and fasts seasonally. In other words, little or no feeding takes place on the breeding grounds during the winter and little or no breeding takes place on the feeding grounds during the summer. For up to six months each year, during migration and while on the wintering grounds, humpback whales rely on vast stores of lipids, in their blubber and other tissues, to meet their energy demands. They feed on the enormous schools of prey found in their summer retreat from June to early October to replenish their fat reserves and prepare them for another migration south.

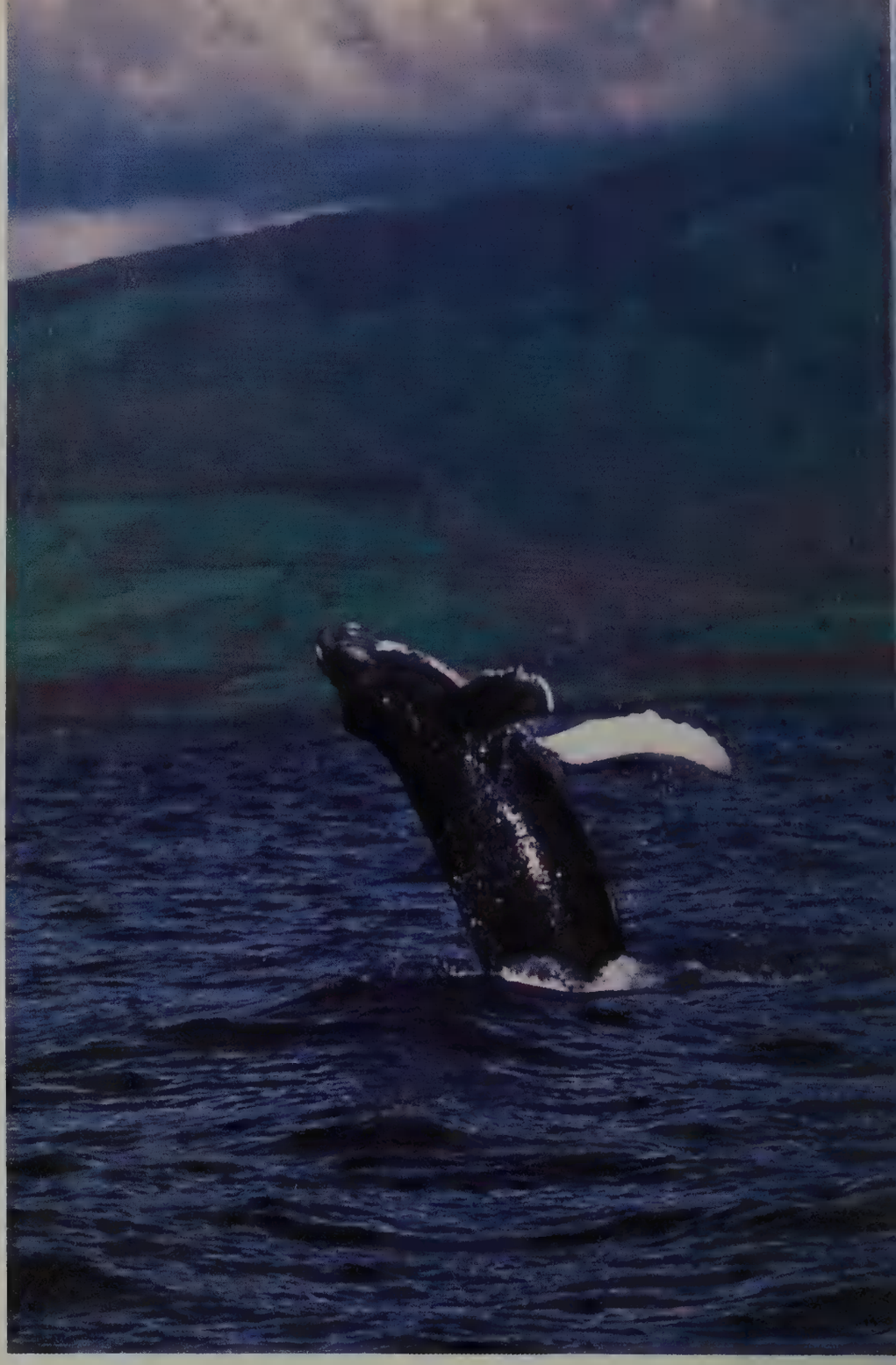
Along with our associates Anjanette Perry, Gordon Bauer, and Paul Forestell of the University of Hawaii, we have studied the migration and social organization of humpback whales in the northern Pacific Ocean for the past ten years. In the summer this study takes us to the calm inshore waters of southeastern Alaska, where an estimated 300 humpback whales go to feed each summer and fall. In the winter we return to Hawaii, where perhaps 500 to 1,000 whales gather to breed and raise their newborn.

Until recently, a major obstacle to understanding the social behavior of humpback whales was the difficulty in determining the sex of individuals. Male and female humpbacks look almost exactly

A feeding group of humpback whales lunges through the surface, taking great mouthfuls of food—usually schooling fish or krill—and sea water. By coordinating their movements, groups of whales may feed more efficiently than solitary eaters. Humpbacks fight during the winter breeding season in Hawaii, but they tolerate each other on their Alaskan feeding grounds from June to October; many team up year after year to fish collectively.

Jan and John Straley

Mark Ferrari; Earthviews



alike; the only way to be sure of an individual's sex is to inspect its genitals. While whalers could easily make this sort of inspection on their flensing decks, the task is considerably more difficult when dealing with whales in the wild.

Fortunately, repeated sightings of individual whales can provide indirect evidence of an animal's gender. By examining photographs of the unique black-and-white patterns on the underside of the tail flukes, we have been able to identify more than 1,200 individual whales in the eastern and central North Pacific. Details of where the animal was sighted, who it was associating with, and what it was doing are stored in a computer library at the University of Hawaii. From these records we can now surmise the sex of several hundred whales.

Observations of the individually identified whales in Hawaii and southeastern Alaska reveal a complex and variable social organization linked to seasonal migration. In Hawaii, the structure of humpback groups centers on male competition for mature females. We often observe aggression when a cow-calf pair is joined by one or more adults. But since the behavior of such escorts is sometimes defensive and sometimes aggressive, we were initially unable to figure out whether they were males courting the cow or females related to her—"aunts" helping to protect the calf. Related females in many other species of long-lived mammals, including dolphins, chimpanzees, and African elephants, help each other in this way. We have observed, however, that the same escort rarely accompanies a cow-calf pair two days in a row. If the escorts were aunts, we would expect them to be with the cow on a regular basis. The brief associations suggest instead that escorts are mature males courting the cows. More direct evidence of this has come from Debbie Glockner-Ferrari, an independent researcher in Hawaii, who has determined the sex of escorts by photographing them under water.

The majority of cow-calf pairs in Hawaii have one or more escorts. A lone escort typically stays behind, and a little below, the cow-calf pair. If another escort attempts to join the trio, the lead escort tries to maintain his proximity to the cow and keep the intruder behind him. But if the new whale persists in trying to approach the cow, he is met by an escalating series of threats from the original suitor.

The first step taken by the aggrieved male in these hostilities is usually to intercept the challenger and block his approach to the cow-calf pair. This preliminary act of aggression, which probably doesn't bring the whales into actual physical contact, occurs under water and is thus difficult to see. But if the situation heats up a little more, the initial escort may try head lunges as a way of displacing the interloper. A head-lunging whale erupts through the surface and engorges the pleats of its throat with water and air, possibly attempting to increase its apparen size. As Darwin first noted in *The Expres sion of Emotions in Man and Animal* one of the most common elements of ag gressive or defensive displays in verte brates is that the animals try to mak themselves look bigger by puffing up thei fur or by inhaling to inflate body size.

Along with head lunging, competin male humpbacks also release air unde water. This behavior, known as bubblin may have originated as a specialized feed ing strategy. In southeastern Alaska, feed ing humpback whales often blow a cylin drical or spiral-shaped curtain of bubble to help contain or concentrate plankto and small fish. Bubble trails in Hawaii ar formed along a straight or slightly curve path, but the intent may be similar. Lik

The humpback breeding ground is often the site of violent conflicts between males and of spectacular aerial displays. Fights often begin when a male escort accompanying a female is challenged by an intruder attempting to displace him. Below: An underwater scrap between two males bursts out into the open. The original escort (right) was tagging along with a cow-calf pair when the antagonist arrived. Left: A female that was being pursued by several sparring males breaches out of the group. The mountains of western Maui are visible in the background.

Mark Ferrari; Humpback Whale Fund

he bubble net, which is thought to disori-ent the whale's prey, bubbling on the mat-ng grounds may confuse a whale's oppo-nent. Having been caught in bubble trails ourselves while observing whales under vater, we can affirm that even a thin cur-ain of bubbles reduces visibility drasti-cally—often to only a few feet.

If head lunging and bubbling still don't esolve the conflict, the lead male may es-calate to a violent charge-strike, a form of ssault in which one whale butts another vith its rostrum (chin) or strikes out with ts flukes. The tips of a whale's flukes and ostrum are sometimes spotted with bar-nacles, adding a "brass knuckle" effect to he blow. In extreme cases, two butting vhales may rise vertically out of the water n a posture that early whalers described s copulation. Our photographs of vertical vhales, however, show that they are posi-ioned stomach to back, which is not the vay other whales and dolphins are known o copulate. And in some instances we now that both individuals were males. Most likely, the whalers simply mistook ighting between males for mating.

Early whalers also misinterpreted, in nany cases, the function of the humpback vhales' spectacular aerial displays—other neasures the whales sometimes adopt in isputes with rivals. The whalers described breaching, lobtailing, and finning accurately, but most of them thought what they were seeing were "gambols," or play. A breaching whale hurls itself out of the water, twisting its body in mid-air, and then lands with a thunderous splash. When lobtailing, a whale slaps its tail flukes against the surface of the water. Finning is similar to lobtailing except that the whale slaps the water with its long flippers instead of its flukes.

While the aerial behavior of a calf may be play (a difficult situation to define), some aerial displays by adults are clearly part of aggressive encounters. On March 15, 1981, near the island of Maui, we saw a cow-calf pair with four aggressive escorts. We identified the lead escort as Arrow, a male with an extensive history of escorting. For more than an hour, Arrow lunged and physically displaced the other escorts, driving them back from the mother and calf. Following a violent charge-strike by Arrow, one of the trailing escorts lobtailed six times and left the pod. Within a few minutes the others also left, leaving Arrow alone with the pair.

On another occasion, we found a cow-calf pair resting near the surface with a single escort. Another whale rapidly approached the trio and breached when it was a few hundred feet away. The female's initial escort quickly moved to block the newcomer, and the four whales moved off uneasily, the males sparring intensely in an attempt to get in the lead.

Unlike head lunges and charge-strikes, however, a whale's aerial behavior is not used solely for aggression. Breaching, lobtailing, and finning also are used in apparently amicable situations in Hawaii when whales come together or split up. On the feeding grounds in southeastern Alaska, a whale may breach as it joins another whale in feeding. When feeding whales disperse, we often see aerial displays. Hal Whitehead, in his work with humpback whales feeding off Newfoundland, found a similar correlation between aerial displays and changes in the composition of whale groups.

Aerial behavior is related to at least one other circumstance—human activity. In southeastern Alaska, humpback whales may breach or otherwise react strongly to passing ships or boats. Once we watched as a 600-foot cruise ship passed by a pod of three adults and a calf feeding in a small cove. Although the ship remained more than a mile away from the pod, the whales breached twenty-two times in a row as it approached. From underwater recordings made at the time, we found that the breaching was closely correlated with sudden increases in noise resulting from changes in the ship's engine speed.

Because aerial display is part of so many situations—changes in group composition, play, aggression, and human disturbance—it is difficult to pinpoint its function. Like the bark of a dog, breaching, finning, and lobtailing may have different meanings in different contexts.

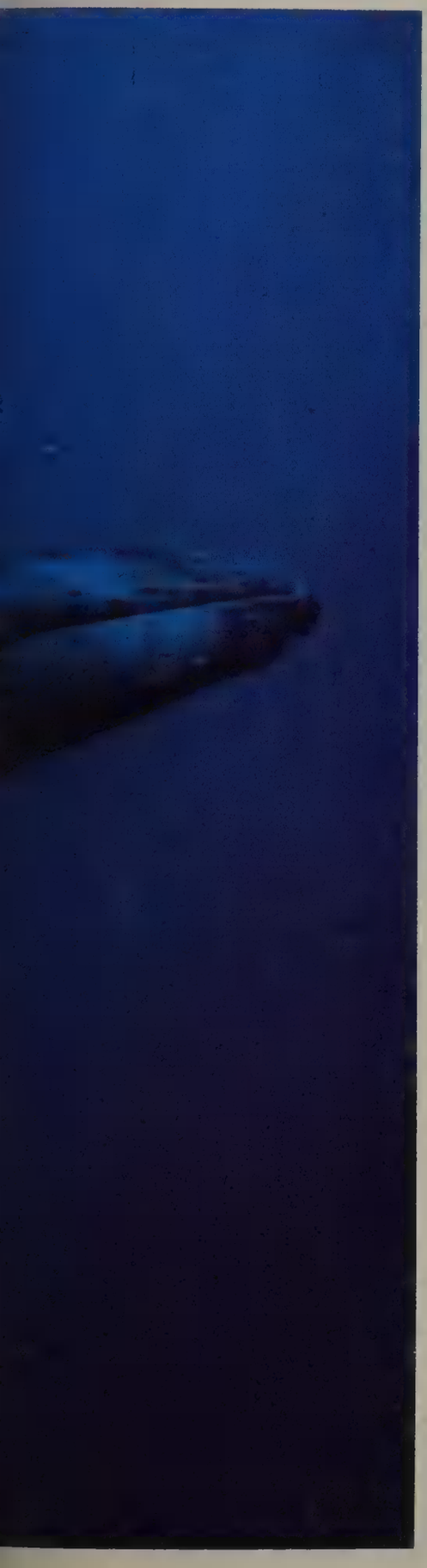
Aggressive encounters between male humpbacks often take place near cow-calf pairs, but males also fight over single females. Most female humpbacks give birth only once every two to three years, so there are seasons when adult females come alone to Hawaii. Large pods of whales without cow-calf pairs are often "surface active," with frequent head lunging, bubbling, and charge-strikes. In some cases, we have discovered a mature female in the lead of these pods with males trailing her. This suggests that surface-active pods are

Off the west coast of Maui, a humpback female and her calf move slowly under water. Calves often remain above their mothers. Females reproduce once every two or three years, so they sometimes come to Hawaii without any young. Whether alone or with calves, females are approached by males that fight to become their escorts and, presumably, their mates.

Deborah A.Glockner-Ferrari; Humpback Whale Fund

A humpback male blows bubbles, one of its strategies for driving off opponents. Bubbling, the release of air from the whale's blowhole or mouth, may confuse a male's rival, for the bubbles drastically reduce visibility. But it may also simply be a threat to an intruding whale.

Deborah A. Glockner-Ferrari; Humpback Whale Fund



aggregations of males competing for proximity to a mature female.

The behavior of escorts with cow-calf pairs and males in surface-active pods closely resembles that of "tending" males in many ungulate species. Among moose and gazelles, for example, a tending male temporarily associates with a preestrous female during rutting season and defends her against other prospective suitors. Like the humpback whale escort with his cow-calf pair, the association between the tending male and female ungulate is brief, lasting from less than an hour to at most a few days. If he is undisturbed by rivals, the tending male simply follows the female until she signals her intent to mate by stopping; at this point, the male mounts and copulates. Since no one has ever documented copulation between humpback whales, however, any equating of escorting and tending must remain tentative.

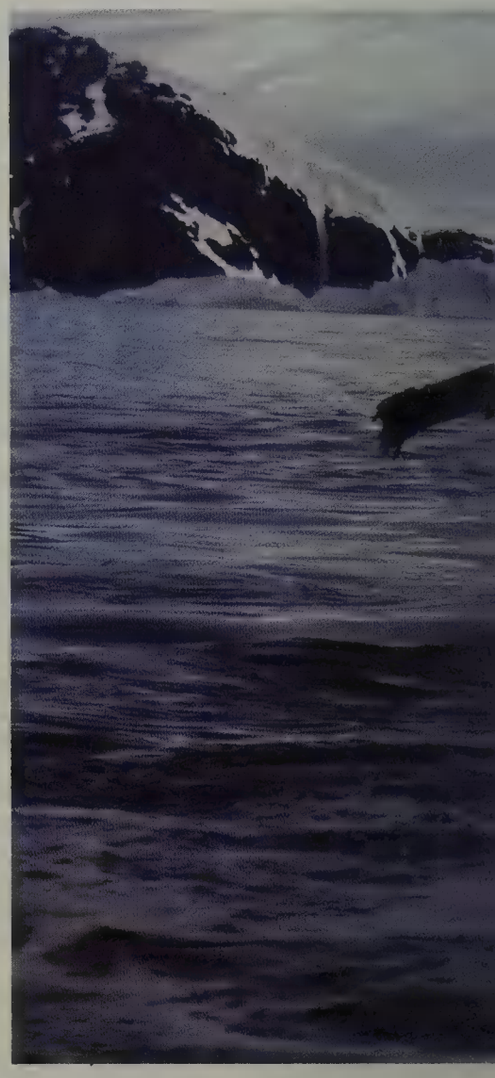
The absence of documented matings between humpback whales is disappointing but not inexplicable. The whales are usually visible at the surface for only a few minutes out of each hour. Underwater observations of whales are limited by the speed and depth of the whale—it is impossible for a human diver to follow even a slow-moving whale for more than a few minutes. Considering that copulation is very brief in many mammals, the apparent modesty of humpback whales is really not too surprising.

We do have a good idea of when mating takes place. In a few cases, we have documented that a female accompanied by males one winter was back with a calf the next. Since humpback whale gestation is eleven to twelve months, mating must have occurred sometime near the period that the female was associated with the males. For example, on March 2, 1981, we spotted a female humpback near the island of Maui, accompanied by a single male. We next sighted her a month later near the island of Kauai, 240 miles away. At this time she was leading a surface-active pod, which included five other adults aggressively competing to get near her. She returned to Maui the next year, accompanied by a newborn calf.

Not only are the associations between cow-calf pairs and escorts transitory but the whole structure of humpback whale pods in Hawaii is very fluid. Joseph Mobley, who worked with us there, found pods gain or lose a member about once every seven hours. Larger pods tend to gain and lose members more rapidly than smaller ones. Likewise, we have sighted and identified whales extensively, but we have rarely seen the same two whales to-

Breaching, in which whales hurl themselves vertically out of the water and land with a thunderous crash, can be aggressive, but whales also breach in seemingly amicable situations. For example, humpback whales may breach when they meet up or separate on the feeding grounds, and young humpbacks may breach as a form of play. Thus a breach, such as the one below, may have different meanings in different contexts.

John Dominis: Wheeler Pictures



gether twice on the breeding grounds.

In the past, commercial whalers and whaling biologists believed that all baleen whales formed monogamous pairs or small family groups. But this assumption was based upon the sexual composition of a few groups of whales that had been killed. Our observations of pod structure and aggressive competition between males now suggest quite a different mating system for humpbacks. Sighting histories of individual whales show that during a single winter, females are seen both serially and simultaneously with many males, whereas males are seen serially, but not simultaneously, with many females. This pattern indicates that humpback whales are either polygynous or promiscuous. In a polygynous mating system, males attempt to mate with many females but females usually mate with a single male. In a promiscuous system, both females and males may mate with several individuals. Until we are able to document copulation between identified whales, we cannot determine which of these two mating systems accurately describes humpback behavior.

As the whales arrive in southeastern Alaska during late spring and early summer, serious attention turns from mating to feeding. Humpback whales will feed on prey ranging from half-inch-long euphausiids, or krill (a planktonic crustacean), to fish ten inches long. Social organization during feeding is strongly influenced by the varying sizes and types of prey. We have found at least two distinct feeding patterns—fluid associations between individuals feeding on swarming euphausiids, and stable associations among individuals feeding on schooling fish.

Early in the summer, when euphausiids are scarce, most humpback whales are solitary or form small pods. As euphausiids begin to swarm and concentrate during late summer and early fall, up to forty whales may aggregate in areas only a mile in diameter. Early whalers referred to these groups as shoals. Within these shoals, whales casually join and leave smaller pods of four or fewer members.

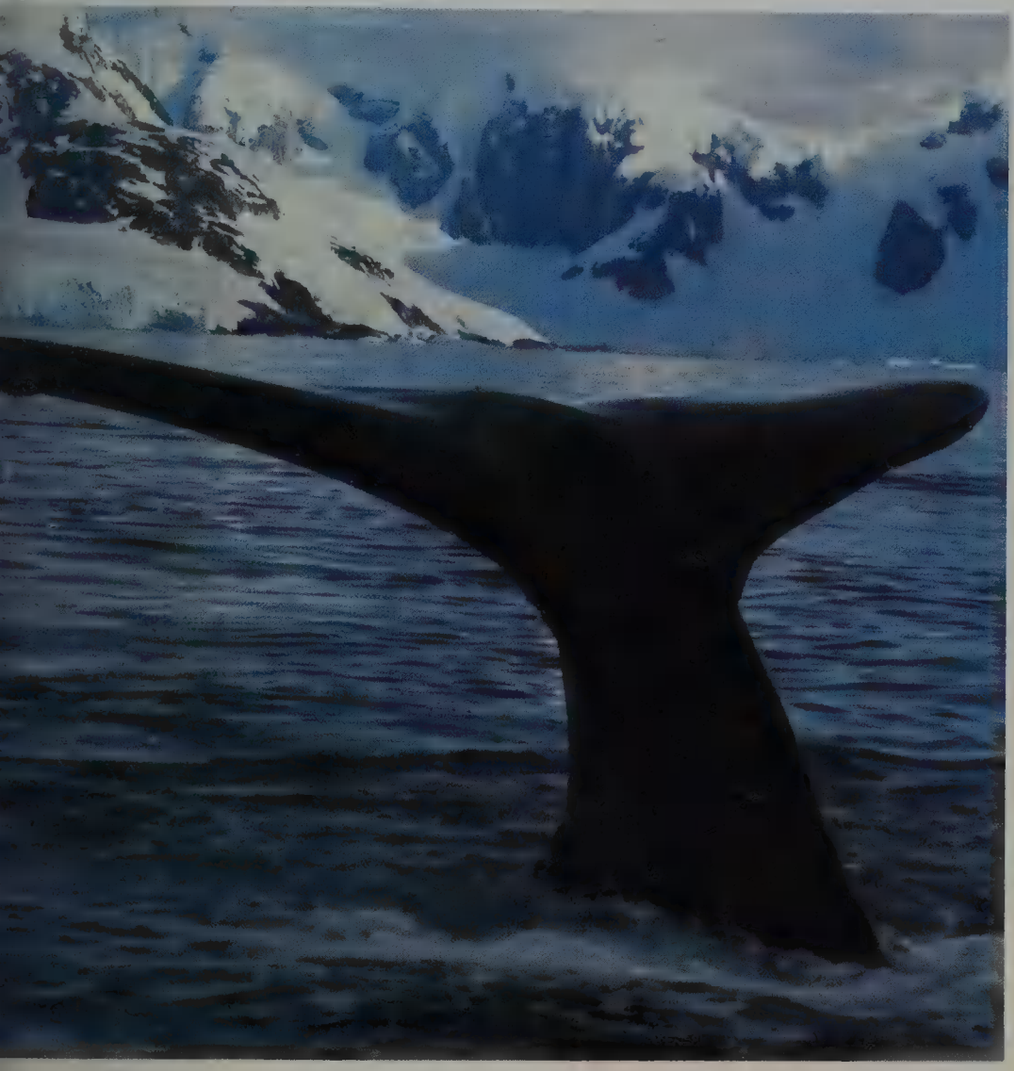
Although both feeding groups and mating groups are fluid in terms of individual membership, their sexual composition and behavior differ markedly. There are no rigid rules for associations between the sexes in southeastern Alaska, for example. Feeding groups may be all males, all females, or males and females. And cow-calf pairs are generally solitary. When they do spend time with other whales, the others can be of either sex.

Most striking to us is that humpback whales show little evidence of aggressior or competition on the feeding grounds. In stead, they appear to be quite tolerant o each other. They may even engage in co operative strategies such as echelon feed ing. As first described by biologist Charle Jurasz, echelon feeding involves two t four whales lunge feeding in close syn chrony. During each lunge, the whales ar parallel to each other, separated by half body length. The echelon formation re quires loosely coordinated movements an presumably increases the feeding effi ciency of the individuals involved.

But humpback cooperation can go fa beyond this casual level. For the past fou years we have observed a cohesive grou of six whales that establishes a seasona home range in Icy Strait, just outside Gla cier Bay National Park. In 1981 we wer able to observe the group on only one da

The huge tail fluke of a Southern Hemisphere humpback whale disappears into waters near Antarctica. The southern population of humpbacks feeds in icy antarctic waters and breeds in the warmer oceans to the north.

Douglas T. Cheeseman, Jr.; Peter Arnold, Inc.



but we know that the six whales remained together during the summers of 1982 and 1983. Studies conducted by Ken Krieger and Bruce Wing, of the Auke Bay Laboratory of the National Marine Fisheries Service, show that these whales were feeding primarily on schools of herring at a depth of 60 to 140 feet.

Admission to the Icy Strait group appears to be affected by an animal's sex and reproductive stage. From our own data, as well as earlier observations by Jurasz, we believe that five of these whales are mature females. We have not yet determined the sex of the sixth member. In the years that any member was accompanied by a calf, she did not join the group. In 1984 several of the members returned to southeastern Alaska with calves, and the group did not form at all. The remaining members without calves did not associate with other whales. This summer (1985), five of the six whales returned to Icy Strait without a calf. These five whales have rejoined and are feeding together with the same esprit de corps.

While the Icy Strait feeding group tends to remain together in a small home range, other feeding groups travel together like a pack of wolves or a pod of killer whales. On July 17, 1981, in Frederick Sound, we saw eight to ten whales diving and lunging together as a group through the center of a single bubble net nearly seventy-five feet in diameter. This coordinated feeding behavior was similar to what Jan and John Straley observed in their study of late-season whales in nearby Seymour Canal (see "Whales at Table," by James W. Greenough, *Natural History*, December 1981). As the whales lunged simultaneously through the surface, we could see herring leaping out of the water in an unsuccessful attempt to avoid their gaping jaws. Three days later we found the group feeding in the same location. Then, two months later, we found them lunge feeding in Chatham Strait, more than eighty-five miles away. In 1984 we again found roughly the same feeding group in three different areas of southeastern Alaska. Photographs show that many of the same whales were in all six of these groups. Adult females seemed to predominate among the regulars in these groups, but males were also present. To our knowledge, this is one of the most remarkable records of social stability and coordinated movement among baleen whales.

The group's method of feeding was also intriguing. By monitoring underwater sounds, we found that one or two whales would give a series of trumpetlike calls as the group was ascending to the surface. These calls were rhythmic and lasted about forty-five seconds, rising in pitch near the end. We recorded them in 1981 and 1984 and found they were identical. In general, humpback vocalizations on the feeding ground are sporadic and are not as long and complicated as the better-known "song" from the mating grounds. Given the circumstances, we believe the feeding calls have one of three possible functions. They either help synchronize the whales in their surfacings, help the caller to maintain social dominance over the group, or serve to disorient the schools of fish the group is preying on.

Why do humpbacks bother to feed on elusive schooling fish when slow-swimming euphausiids are easier to catch? Swarming euphausiids may not be readily available each season or during all times of the season. The recent studies of Wing and Krieger show that the abundance and distribution of whale prey vary significantly. We have also found that the nutritional value of some schooling fish may be far superior to that of euphausiids—herring, for example, may provide 50 percent more calories in equal volumes. This is an attractive benefit for an animal with only a few months to gather its food for the entire year. Like the pack-hunting strategy of social carnivores, cooperative feeding

C. Scott Baker

The return of the whales from Hawaii to the waters of southeast Alaska marks the end of hostilities. The humpbacks begin to fraternize again. Early in the summer they may form small pods, below, that feed on krill, a planktonic crustacean. A little later, when schools of fish appear, the whales may band together in larger, more stable groups. These cliques sometimes remain together the entire summer. Right: A vertical club of humpbacks gorge on herring in a synchronized lunge-feeding maneuver.

William Stifel, Kewalo Basin Marine Mammal Laboratory

may allow humpback whales to exploit a rich source of energy unavailable to solitary feeders.

While migration has a profound influence on seasonal changes in the social behavior of humpbacks, the basic social requirements of whales may in turn determine the pattern of migration. By comparing identification photographs collected by researchers working in other regions, we have begun to trace the movement of humpback whales throughout the central and eastern North Pacific. The results, so far, suggest that North Pacific humpback whales form a structured stock, a series of geographically isolated feeding herds that may include groups of related whales. The waters of southeastern Alaska, for example, seem to support one such feeding herd that is segregated from others to the west. Whales from southeastern Alaska assemble with other feeding herds on the Hawaiian wintering grounds to form a large breeding group. From photographs taken by biologist William Lawton, we also know that some whales from southeastern Alaska migrate to a second wintering ground near the Baja California peninsula of Mexico. Research by Jim Darling and Charles Jurasz has shown that some individuals may go to Hawaii one year and to Mexico in another. What all of this implies is that the humpbacks have evolved a strategy of feeding cooperatively with relatives and competing with strangers for breeding partners—and this may explain their pattern of migration.

We hope to expand our study to include the feeding and breeding grounds of humpback whales along the Asian coast of the North Pacific. Humpback whales in this region were intensively hunted by shore-based whalers until the early 1960s. But now almost nothing is known about their distribution or numbers. Early whalers believed that these whales formed an "Asian stock," which remained isolated from an "American stock" in the eastern North Pacific. But it also seems possible that humpback whales throughout the North Pacific form a single structured stock, with whales from several feeding herds traveling to any of the three breeding grounds—Mexico, Hawaii, or Asia.

After ten years, we are just beginning to form a picture of humpback whale behavior and migration in the eastern and central North Pacific. But when one is studying an animal with a life span of possibly forty years or more, ten years can only be a beginning. By following the life histories of individual whales, we can continue exploring for decades the role of competition and cooperation in this species. □

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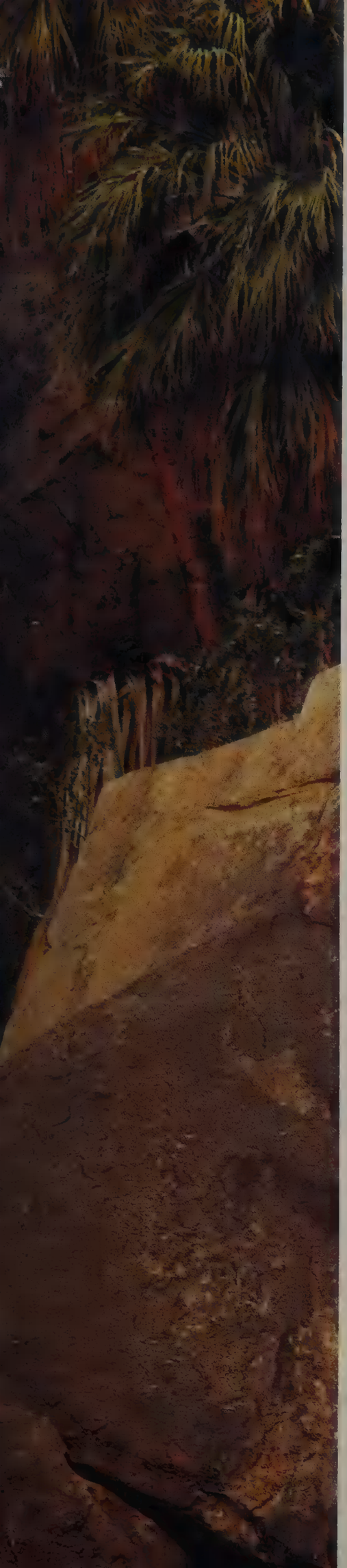


Nicknamed petticoat palms because of the skirts of dead leaves that hang around their trunks, fan palms are the largest native palm trees of the continental United States.
David Muench

Reading the Fan Palms

We know where these trees grow, but we're not sure how they got there

by James W. Cornett

The Colorado Desert—which reaches from the edge of Arizona into southeastern California and down into Baja California—is an arid, low-lying region of shifting sand dunes and stony flats. In July the temperature often rises above 110 degrees Fahrenheit, and the average annual rainfall barely reaches three inches. It is one of the last places on the North American continent where one might expect to find verdant groves of palm trees, yet desert fan palms (*Washingtonia filifera*) do exist here. The trees thrive near the occasional stream, spring, or seep, sometimes growing to seventy-six feet in height and forty inches in width. Their stout trunks are typically shrouded by ground-length skirts of dead fronds, but sometimes those coverings have been burned away. This species is the only endemic palm in the western United States and the most massive in all of North America.

These palm oases—"tropical islands" tucked away in such remote places as Lost Palms Canyon, Hidden Spring, and Surprise Canyon—had piqued my curiosity for two decades. I wondered how the palms had become established in such out-of-the-way sites. Were the trees ancient residents or new arrivals? And what determined the size and vitality of the groves? How did they spread from one distant spring to another, if indeed they did? With the aid of a grant from the R.K. Mellon Foundation, my co-workers at the Palm Springs Desert Museum in California and I were able to embark on a three-year search for answers to these questions.

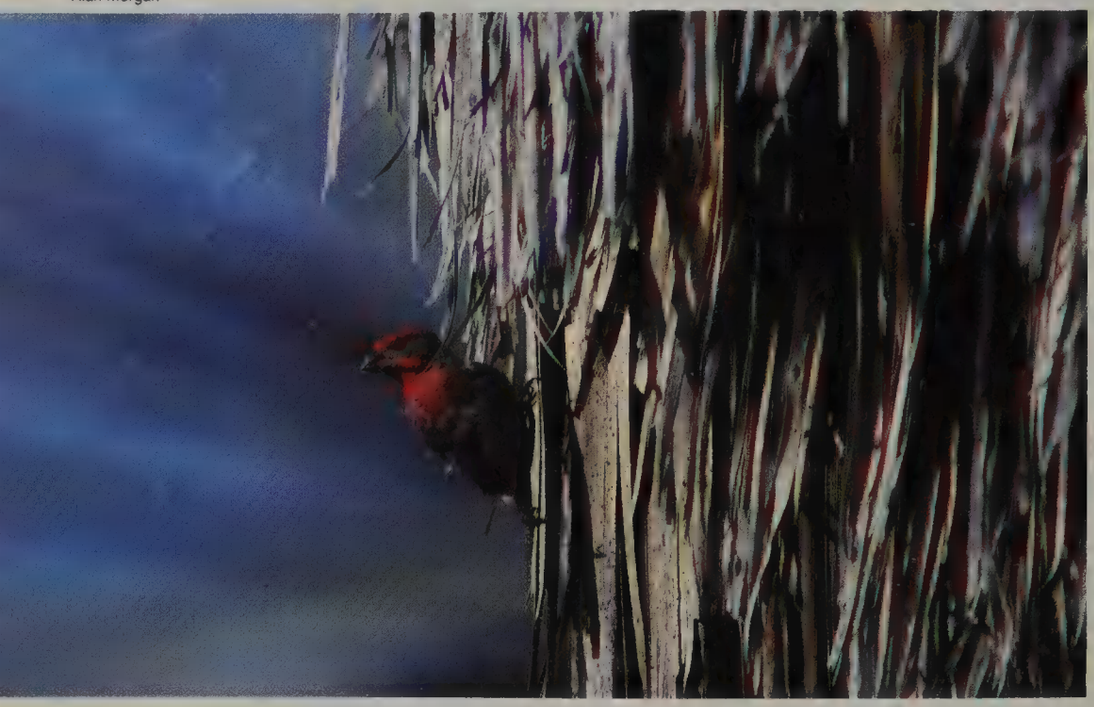
The desert can be a lonely place in which to conduct ecological studies, but to our delight, we were seldom alone in an oasis. These verdant outposts attract an abundance of birds, which come to feed, drink, and rest among the palms. More than eighty avian species use these "pit stops" on their migratory journeys. Some of our more startling sightings included snow geese coming down their flyway on the way from Canada to the Salton Sea, as well as American avocets and belted kingfishers. Nearly two dozen other bird species are known to nest in the oases, and for most of them there are no other satisfactory nesting sites for miles around. Mourning doves, owls, roadrunners, and house finches frequently rear their young in the thick skirts of the palm trees. Brightly colored hooded orioles use palm leaf fibers for their basketlike nests, which they attach to the underside of a palm leaf.

Oases also attract many kinds of mammals. Where there are palms, there is often drinking water nearby, and the trees' great height—the equivalent of a six- or seven-story building—can serve as a distant visual signal to birds, coyotes, and bighorn sheep. Rams and ewes are occasionally seen near the oases, and their droppings are regularly observed. The western yellow bat, as far as is known, is restricted to the vicinity of palm oases where it roosts under the trees' skirts during daylight hours. The ubiquitous raccoon, although not really a desert animal, has been able to disperse into the largest of these remote sites. In several cases the raccoons must have crossed miles of inhospitable desert and then become trapped in the islandlike environment of an oasis. Coyotes are the most conspicuous large mammals drawn to palm oases. Because they gorge themselves on the palm fruits, they visit every grove, even those where drinking water is not available.

Healthy, mature fan palms produce up to half a million fruits each fall. These pea-sized dates possess a sweet-tasting flesh, similar to that of commercially marketed dates. Unfortunately for humans, the seed occupies most of the fruit and is rock-hard.

The house finch is one of at least eighty bird species sighted in fan palm oases. It often nests and rears its offspring in the trees' leaf skirts.

Alan Morgan



That makes the fruit nearly impossible to eat. Two migratory species—western bluebirds and cedar waxwings—feed extensively on the rind but consistently discard the seeds. In the laboratory, cactus mice and antelope ground squirrels also eat the rind but only consume the seeds if the alternative is starvation. Only the spiny pocket mouse eats the entire fruit, yet even this species loses weight on a diet of nothing but palm fruits and would probably die without supplementary foods.

Coyotes digest only the flesh of the date and pass the intact seeds in their droppings. In the late fall and winter, when the palms are in fruit, coyote droppings may contain hundreds of palm seeds. We were surprised to learn that not only did these seeds germinate after their intestinal travels but they also did so in less time and with twice the success of unconsumed seeds. Coyotes are also known to travel up to thirty-six miles in three days, probably the maximum time that palm seeds can remain in the digestive tract of a healthy animal. Thus coyotes may be the most important dispersal agents of the palms' seeds and could have transported them to almost all of the known fan palm sites. The only three exceptions are a group of five trees at Mopah Spring in California's Turtle Mountains and oases in the Kofa Mountains and at Castle Creek, both in the Sonoran Desert of Arizona. These three sites have had palms for as long as anybody can remember, and each is more than seventy miles from the next nearest palm oasis, too far for coyote dispersal. Since the seeds are too heavy to be transported by the wind, how did these isolated groves come into being?

One explanation for their existence is that they are relict populations, left over from a time when palms were more abundant and more widely distributed. Fifty million years ago, during the Tertiary period, the climate in western North America was warmer and more humid than it is now. Springs, streams, and lakes were relatively common and provided the large quantities of water required by palms. Palm fossils indicate that these conditions were widespread and existed as far north as Alaska. Much later, during the Pleistocene epoch, about two million years ago, increasing aridity and periods of cooler temperatures forced the palms, as well as many other types of subtropical vegetation, southward into what is now the Sonoran Desert. With the drying out of the Southwest since the Pleistocene, many, and ultimately most, of the springs and seeps disappeared. The result has been the restriction of palms to the few places

Cottonwoods have longer roots than fan palms and therefore have a competitive edge even where water collects, as in this region of Guadalupe Canyon in Baja California.
David Cavagnaro

where faults and fractures allow ground water to reach the surface and along streams that drain the mountain peaks forming the western edge of the Colorado Desert.

Are all palm oases, then, relict populations? In an attempt to answer this question, we searched for some clue that would help us determine whether a specific palm oasis was indeed a relict population or the result of a recent, possibly human introduction. Palms are almost impossible to date because they don't produce growth rings in their trunks. Even if we had encountered a very old tree, we could not have assigned an age to it that might have placed it at a spring prior to Indian occupation or at least the very recent arrival of white settlers. Nor could we find any fossils near the sites of present-day oases. We had nearly given up trying to determine the question of origin when Kenneth Cooper, a retired biology professor from the University of California, suggested that the answer might lie with the palm's only deadly parasite—the giant palm-boring beetle.

Almost without exception, mature fan palms possess one or more half-inch holes in their trunks. These are the exit burrows of the parasitic beetle known to entomologists as *Dinapate wrightii*. The larvae of these beetles spend up to six years feeding on the woody interior of a trunk (sometimes killing the tree) before pupating and chewing their way out. Upon emergence, males and females fly off to mate in the crown of a palm. We have found only three oases in which we saw no exit holes and where the palm borers did not exist. These were the three most isolated sites: Castle Creek, Kofa Palm Canyon, and Mopah Spring. If those groves had been around when palms had a continuous distribution, the beetles should have reached them. The absence of the beetles suggests these palm oases were not present during past geological epochs and therefore are not relict populations.

If their seeds were not dispersed by coyotes, how then did the palms reach these remote locations? The most likely explanation is that the seeds were purposefully brought in by humans. We know that

A fan palm oasis thrives in a desert area. Wherever palms grow, water, although not always seen, cannot be far away.

Peter Menzel

Undeterred by the spiky edges of a fan palm frond, a roadrunner eats a small lizard it has caught.

James W. Cornett

Native Americans often transported seeds from one place to another, as demonstrated by the spread of corn throughout the New World. The abundant potsherds, bedrock mortars, and rock carvings around palm oases indicate that in southern California, Indians did live in or near the oases, and other archeological and ethnographic evidence indicates that they ground the palm fruits into flour, made baskets from the palm leaf fibers, and covered their homes with palm fronds. It seems reasonable, therefore, to assume that the same Indians introduced the useful fan palm to new regions. Today's Cahuilla Indians, living in the Colorado Desert, have told us that their ancestors distributed fan palm seeds when they moved from one region to another.

Although the dispersal of seed is necessary for the spread of most plant species, Indians played an even more important role in palm oasis ecology. The Cahuilla of southern California regularly set fire to palm oases to clean debris from an oasis floor. (Most mature trees are rarely killed by fire since their vascular bundles are strewn throughout the trunk, but this is not true of conifers and such trees as oaks, which are prone to heat damage because they possess a vulnerable layer of cells, called a cambium, just beneath the bark.) The Indians also knew that burning increased fruit production and killed the beetle larvae gnawing at the tree's interior. Setting fires, probably under carefully managed conditions, not only enhanced the harvest of palm fruit but also favored the survival of the palms by eliminating or reducing competitor tree species that are less tolerant of heat.

When my co-workers and I began our research on the ecology of desert fan palm oases in 1981, we knew that many oases had been named at the turn of the century for the number of palms they contained—for example, Una Palma, Dos Palmas, Five Palms, Twelve Apostles, Seventeen Palms, and Twenty-nine Palms. But when we visited those sites between 1981 and 1984, the names did not jibe with our counts. Una Palma had 3 trees, Dos Palmas had 308, the Twelve Apostles had vanished, and Seventeen Palms was more like the Twenty-nine Palms site, which had 36 trees. At first, we did not know how to interpret our count. Two earlier palm researchers had outlined a bleak picture, stating that palm oases were "being disturbed or destroyed by urban development and a reduction of natural water supplies." We also knew of destruction caused by countless fires set by vandals, by the introduction of the invasive tama-

Hooded orioles build their basketlike nests out of the fibers of fan palm leaves. They attach the nests to the undersides of leaves high above the ground, where the young are safe from predators.

James W. Cornett

risk shrub, which crowds out other plants, and by the incursion of hikers and campers into many oases each weekend. But our preliminary results suggested that palm populations might nevertheless be growing rather than shrinking.

During our studies, we visited most of the palm oases within the natural range of *Washingtonia filifera*. Fortunately, the late Randall Henderson, editor and publisher of *Desert* magazine, had visited those oases decades before and had painstakingly counted the palms in nearly every oasis in the Southwest, describing their condition, their associated vegetation, and the location and amount of water. His articles, which appeared over a 25-year period, were the basis for our comparisons.

We were surprised by what we found. Palm numbers were increasing at a dramatic rate. Sixty-five percent of the 110 palm oases that Henderson had investigated now had more adult trees. In some cases the increases were staggering. Willis Palms, which had 370 trees in 1964, had grown to 612 individuals by 1983. Andreas Canyon, near Palm Springs, California, grew from 322 palms in 1935 to 1,157 in 1984, an increase of 259 percent in forty-nine years. In several instances new groups of palms had sprung up where none existed before. There were at least three new oases in the center of the Colorado Desert just east of the huge inland body of brackish water known as the Salton Sea, and we discovered two new oases in Anza-Borrego Desert State Park in the eastern half of San Diego County. Fan palms have spread into southern Nevada at Rogers and Moapa springs, now the most northerly sites of this species. Our estimates place the current population of wild fan palms at approximately 19,000 individuals, up 40 percent since 1945. What had been happening that could account for such an impressive increase in the numbers and distribution of this plant?

As already mentioned, we knew that Indians set fires to clean oases floors of debris and permit the harvesting of the palms' fruit. We learned that ten years after a fire, the fallen flower stalks, fronds, and trunks pile up again, making it difficult to walk through an oasis. Twenty years after a fire, the debris is so deep and unstable that walking through an oasis can actually be hazardous: one step on the end of an eight-foot flower stalk can result in a blow to the head that is akin to stepping on a hoe. (It took our team an embarrassing number of mishaps to learn this bit of palm lore.) In addition, rattlesnakes use the litter as shelter and we met up with these oasis inhabitants many times. It was

Despite the obvious aridity of this region of Anza-Borrego Desert State Park, a flourishing fan palm oasis has evolved in a shallow trough.

Willard Clay

Coyotes are among the large mammals attracted to fan palms. They feed on the trees' sweet, pea-sized fruit and pass the seeds in their feces. Because the seeds are still able to germinate, coyotes are deemed an important agent in the spread of palms to new oases.

John S. Flannery; Bruce Coleman, Inc.

Fifty years ago there were 322 palms in Andreas Canyon, near Palm Springs. By 1984, the oasis had 1,157 palms. Periods of above-average rainfall are largely responsible for this impressive increase.

David Muench

easy for us to understand why Indians burned oases, perhaps every ten years, certainly every twenty. But with the permanent departure of Indians from the vicinity of palm oases in the late nineteenth century, the pattern of burning was altered, and for fifty years fire was all but absent in the palm oases.

Henderson's articles and photographs indicate that from 1890 until 1940 the size of palm oases had either stabilized or decreased slightly. The absence of fire allowed the palm litter to accumulate to depths that inhibited the germination and growth of young palms. Photographs taken in the Colorado Desert by Stephen Willard, one of the West's first desert landscape photographers, in the 1930s show stands of adult trees with leaf skirts to the ground and few, if any, young palms. Cottonwoods and sycamores, co mon plant associates, appeared to crowding out the palms. The former ha longer, but less dense, root systems a probably had a competitive advanta over the palms throughout the long-ter drought that lasted from the 1920s 1939. Then, after World War II, palm o ses suddenly began expanding.

Two things set the stage for that expa sion. First, from 1939 through 1945, the was a twofold increase in precipitation southeastern California. This change w accompanied and followed by an increa in the frequency of wildfires. (The i crease resulted from the buildup a accumulation of vegetation, which act as fuel, and the influx of settlers into t Southwest. Most palm oases fires a started by people.) The sudden loss transpiring plants after a fire also result in an increase of water flow at the surfac Palm seeds sprout like weeds when sca tered over moist, barren soil and, in ge eral, those were the prevailing conditio in many oases in the 1940s. Although thirty-year drought began in 1946, ma young palms were already established that time. Today, the postwar boom ca be seen as a distinct generation of thirt to forty-foot trees and accounts for th large increases observed in our study.

In 1976 the rains returned with a ve geance to the same Colorado Desert r gion, and greater-than-normal annu rainfall persisted through 1983. Now new generation of young palms h emerged. A cyclic pattern of change the size of a tree population is not uniqu to fan palms; it is a common form of su vival of many organisms that live in r gions with extremes of rainfall. In desert it is the scarcity of water, more than an thing else, that limits the growth of pop lations and individuals. The success most desert species depends on their ab ity to expand their populations rapid during periods of above-average rainfa so that some individuals will be able to su vive the inevitable drought ahead. In th case of the desert fan palm, both wat and fire determine its success or failure maintaining a foothold in the remote oas of the Colorado Desert.

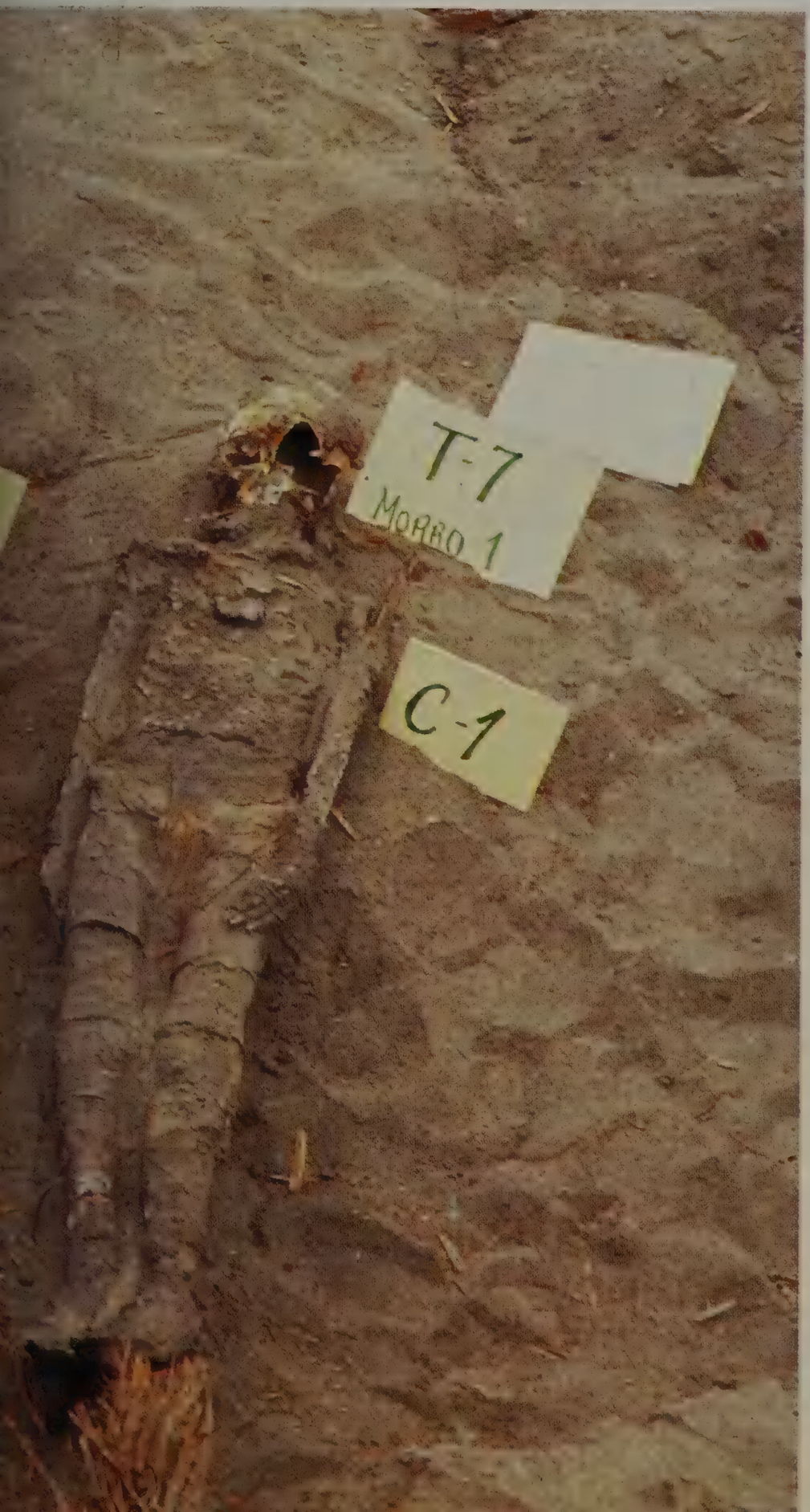
In 1983, workmen digging a trench for a new waterline in Arica, Chile, disturbed a pre-Columbian burial site. Archeologists who were summoned following the discovery salvaged nearly one hundred mummies, including this familylike group.

Marvin J. Allison

Chile's Ancient Mummies

More than 7,000 years ago, hunter-gatherers used elaborate techniques to preserve their dead

by Marvin J. Allison



Arica, Chile's northernmost port, thrives in defiance of the arid lands that surround it. The lifeline for the city and its more than 100,000 inhabitants is the San Juan River, a tiny line of fresh, sweet water that threads its way out of the Andean foothills and across some seventy-five miles of the world's driest desert to the Pacific Ocean.

A tall promontory, El Morro, looms above the southern edge of the city. Late in 1983, a ditch-digging machine was cutting a trench for a new waterline on El Morro's lower slopes when its blades began to churn up the legs and broken bodies of men, women, and children. The pipeline project had intruded into a pre-Columbian graveyard. Work stopped, an archeologist from Arica's University of Taracapá was called in, and a salvage operation was begun. In time, teams of archeologists and students uncovered the remains of 96 individuals, a most valuable addition to the growing collection of more than 1,500 mummies at the university's Museum of Archeology, where I and other investigators have been studying them for years.

With ever improving techniques of analysis and dating, these mummies, along with smaller collections at other institutions in Chile, are providing unprecedented insights into the early history of human disease, nutrition, and culture, including a practice of mummification more complex than the Egyptian process, even though it is two to three thousand years older. Our oldest specimens are, by far, the oldest-known mummies in the world.

Mummification can occur naturally, with the right environmental conditions, or artificially, when humans take steps to preserve a corpse. The conditions in northern Chile are excellent for natural mummification. Because the cold Humboldt current upwells off the coast, the warmer air collects little moisture from the Pacific Ocean. Thus, from the coast to the foothills of the Andes, it almost never rains. Years pass without rain, and in those rare years when some rain does fall, it is not heavy enough to penetrate a foot or more of soil. The absence of moisture—not just for years or centuries but for millennia—is

Lee Boltin

A pelican beak, below, was one of several contained in grave sites. Its sharpened end was an effective tool for skinning sea lions and also for removing the skins from human bodies to prepare them for mummification. The mummy of a male Indian, right, is well preserved after some 4,000 years of burial in arid soil.

Lee Boltin

the main reason for this unsurpassed collection of mummies.

Bodies discovered in an unmarked colonial graveyard about ten miles east of Arica at the Church of San Miguel illustrate the importance of aridity. The small church is next to an ancient Indian burial site where people have been interred—mostly without artificial mummification—for nearly 3,000 years. The corpses of the ancient Indians are dehydrated, but their bones are still firmly attached, their skin and hair still present. In contrast, the remains of the colonials, buried in front of the church, were mostly nothing but bones. We were puzzled by this difference until we discovered that attendants always sprinkled irrigation water around the church to keep down the dust. Moisture, penetrating the soil and the graves, had caused the corpses to deteriorate.

The burial practices of the ancient Indians probably helped preserve the corpses. Bodies were usually placed in shallow holes in seated, huddled positions, and then covered with cloth and reed mats. Under the strong sun, these grave sites were, in effect, solar ovens in which the corpse quickly dried out. In time, windblown sand drifted over the grave, further preserving the cadaver. And finally, the large amounts of salts, including nitrates, in the soil acted as natural preservatives.

In 1919, Max Uhle, the first archeologist to study these mummies, assumed that the natural mummies he found were the oldest and most primitive, while the elaborately prepared artificial mummies were more recent. Without the benefits of modern dating methods, he estimated the primitive mummies were about 2,000 years old. Uhle named these people the Chinchorro, or gill netters, recognizing their maritime location and fishing practices. We still use Uhle's name for these early Americans, as well as his classifications for mummy types, but carbon 14 dating has revealed two surprises.

First, the oldest Chinchorro are four times older than Uhle's estimate. Our oldest mummy has been dated at 7,810 years B.P. (before the present), plus or minus 180 years. Hans Niemeyer, who has excavated Chinchorro sites in the Camarones Valley sixty-five miles south of Arica, has obtained carbon dates of 7,420 B.P. and 7,000 B.P. With a series of carbon 14 dates, using material from the mummies, we now estimate the Chinchorro culture extended roughly from 7,800 to 3,800 B.P. The Chinchorro were probably closely related to another preceramic culture of the area, the Quiani (3,400 to 3,200 B.P.), and to the Faldas de Morro, a group with the

Chinchorro Mummy Sites in Northern Chile

Joe LeMonnier

first ceramics and metals in the area (2,800 B.P.). In short, in one small area we have found human and cultural remains that span a 5,000-year period. And some preliminary genetic and anthropometric studies indicate that all these people were closely related.

The second surprise from the dating was that the 7,800-year-old body, a man of about thirty-five years, was not a natural mummy but was instead an example of one of the most complex forms of mummification. This discovery raises all sorts of questions: Are there older mummies yet to be found? Where did the idea and the skills of mummification come from? How long have humans with complex cultures been in the Americas? These questions, and others, lead to interesting speculations; but since I am a paleopathologist, I spend my time studying the bodies and the artifacts found with them. The data they contain are fascinating enough for me.

The ninety-six bodies from El Morro, as indicated by carbon 14 dates, were interred over a period of more than 3,000 years. They represent all types of mummification, from simple air drying to the elaborate classic style. While there are many variations, all thirty-five classic mummies show the Chinchorro had techniques and a knowledge of anatomy that

Lee Boltin

Below: Two projectile points and a throwing stick, used to propel a spear, were removed from one grave site. Right: A fishnet fragment, found in a grave, is woven out of reeds.

Lee Boltin

contradict any notion that they were primitive, even though they had neither metal nor ceramics.

The first step for a classic mummification involved a careful incision in the cadaver and the removal of the internal organs, which deteriorate quickly. The skin and hair were cut away from the corpse, and major muscles were removed. The brain was removed through an opening cut in the skull or by hooking it out through the foramen magnum (the opening at the base of the skull). All this was done without metal knives. The embalmers used sharpened stones and shells and the sharpened beaks of pelicans. We have found a number of these beaks in grave sites. After 5,000 years they are still sharp, strong, and effective tools.

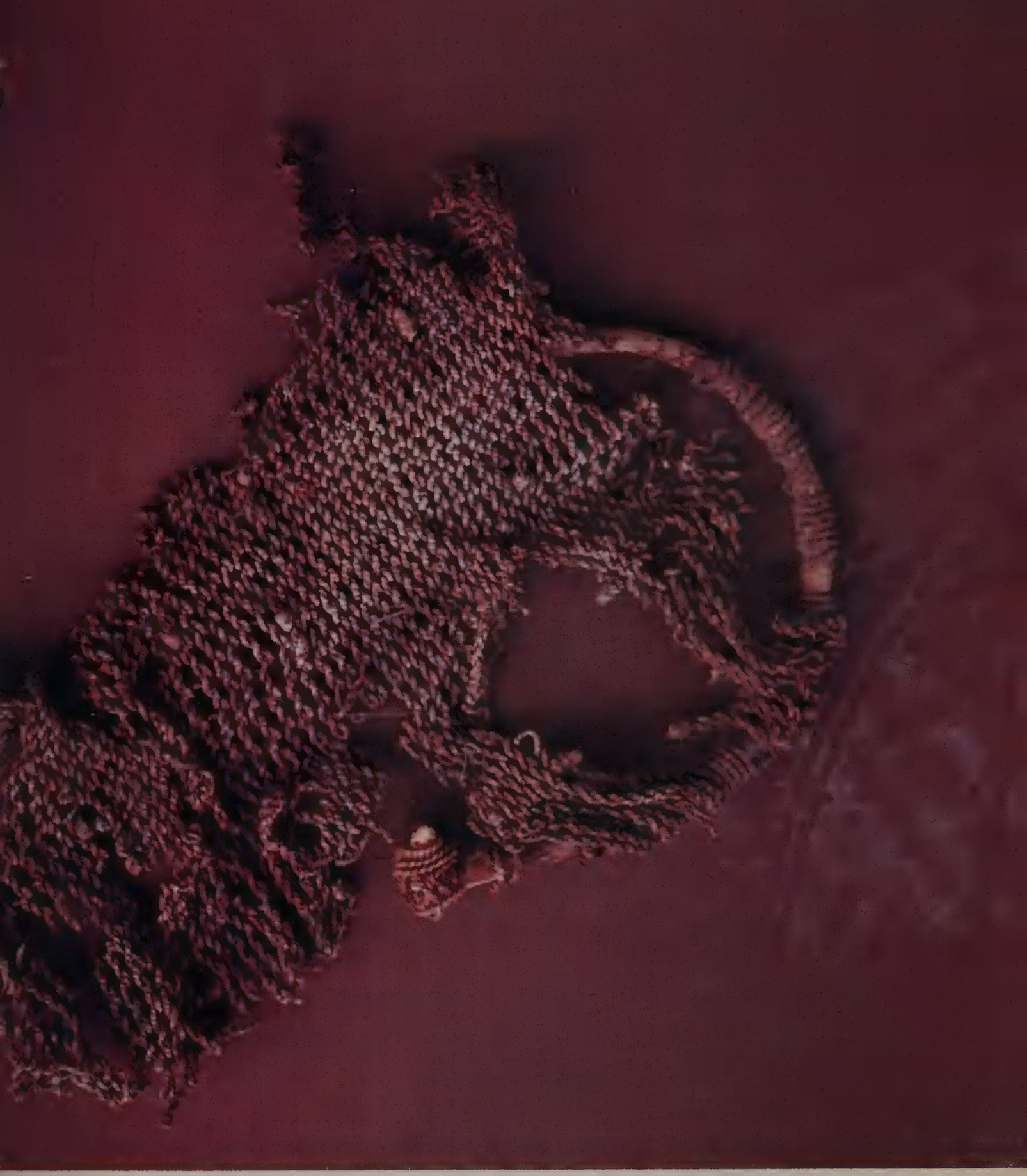
The body was quickly dried by filling it with hot coals and ashes. The skin and hair probably were soaked in salt water. Then the mummy makers—who were most likely specialists in the tribe—took a number of steps to make the corpse rigid. They rubbed the elbow and knee joints with abrasive stones until the bones were flat and then bound them together with fiber ropes. Another fiber rope ran down the arms and across the chest at the level of the collarbones to prevent the chest cavity from flopping open. They drove a sharpened stick under the flesh along the spinal column and tied the vertebrae to this stake. Two other sticks were inserted from each ankle to the skull.

When the body was rigid and dry, the mummy makers wrapped reed matting along the legs and arms, and across the shoulders. They filled the body cavity with wool, feathers, grass, shells, and earth. After binding the halves of the skull together with fiber cord, they wedged it on the ends of wooden poles at the neck and over the rope-bound vertebrae. To give the mummy a lifelike shape, the Indians molded clay over the limbs. Since the kneecaps had been discarded, the skin at the knees was cut and sewed tight.

The mummy makers sculpted a face mask of clay, with holes for the eyes and mouth. They tied the corpse's hair in bunches and bound it to the mask with rope. They painted the mummy black during some periods, red during others.

There were many minor variations from this procedure. Children were often simply eviscerated through an incision in the abdomen and filled with ashes and hot coals. Poles were tied to the legs or slipped under the skin. In other cases, skin on children was cut in strips and wrapped around their bodies like a bandage. With some mummies, the skins of other animals—often pelicans or sea lions—were used t
cover the bodies. In all cases, the idea wa
to make the body rigid and rebuild it t
lifelike dimensions.

When the mummy was finished, it wa
not buried. Apparently as some form o
ancestor worship, mummies were propped
up in groups and continued to inhabit th
community; perhaps in a spiritual sens
they helped to bring good hunting an



shing to their descendants. In return, the ving kept the dead in good condition, as dicated by the repairs on many mum- ies. Eventually, possibly when certain fluential people died, the older mum- ies were buried in small groups. Since any burial groups contained adults and ildren, perhaps the deceased were in- rred as a family.

We also found many plant and animal remains at the grave sites. These materials, along with the mummies and even the campsite dirt stuffed into the mummies, have provided us with many clues about the daily lives of the Chinchorro. The early Indians were hunters and gatherers, living mainly on products from the sea. They used sophisticated gill nets to catch fish off the beaches (a method still used by some Indians in the area today). They hunted sea birds and marine mammals, particularly the sea lion, which they speared with a barbed harpoon.

The Chinchorro did not practice agriculture, with the possible exception of growing reeds for mats and fiber. They used the products of their environment—pelican beaks and feathers, seashells, sea lion hides, and even whalebone—for practically all their needs. We have found

The small wooden mortar and pestle, below, was used for the preparation of narcotic substances, which the Indians may have used for ceremonial purposes. Opposite page: A wooden effigy placed in one grave may have had religious significance for its carvers.

Lee Boltin

some use of rhea skin and feathers and llama wool, which would indicate the coastal Chinchorro traded with the inhabitants of the Andean highlands.

The Chinchorro men suffered from one of the earliest known occupational diseases; one-quarter of them had a bony growth in the ear canal—probably the result of multiple ear infections—that would have led to deafness. Such growths are common in people who dive persistently for shellfish. Since none of the women had this lesion, they apparently did not go shellfishing. The women did, however, have "squatting facets" at the ankle–shinbone joint. These lesions occur when people work in a squatting position—in this case, probably opening shellfish. Nearly half the women had an arthritic degeneration of the neck vertebrae, probably from carrying heavy loads.

This division of labor, as well as the complex processes of mummification, means that individuals among the Chinchorro had specialized jobs and clear roles according to sex. This is unusual for such an early, small, and isolated group of humans. In later cultures, the practice of mummification degenerated, and judging from the hunting and fishing gear we find buried with both women and men, the roles of the sexes merged.

The origin of syphilis has fascinated medical investigators ever since a Barcelona physician, Rodrigo Ruiz de la Isla, reported a new disease brought back from America by some of Columbus's sailors. Throughout the Andean region, bone lesions that might be related to syphilis are found in human remains dating back at least 5,000 years. Bone lesions from a syphilislike disease appear in four of these early inhabitants of the north coast of Chile. We do not know if we are seeing evidence of the venereally transmitted disease syphilis or whether we are dealing with an early nonvenereal form such as yaws, or *pinta*. This will be difficult to answer until we find evidence of disease in the organs or skin.

Osteoporosis, a bone disease in which bone tissue becomes porous and fragile, is a widespread health problem for elderly women in industrialized nations. In virtually all individuals between the ages of forty and fifty, the skeletal mass begins to decline, but in women the rate is faster, possibly because of hormone deficiency. As such, osteoporosis is today's most common metabolic bone disease, but only in a small percentage of the population does it cause serious medical problems. Even so, in 1968 there were 700,000 fractures in women in the United States.

Among the Chinchorro, 31 percen the population had osteoporosis. All sufferers were women, and two-third them were under forty—a much youn involvement than in any other cultu The reasons for the prevalence of this b disease are not yet known. The patter childbearing, the workload, and diet probably all involved. Perhaps these vere cases can shed light on the problen elderly women today.

Because of my interest in patholog usually focus on diseases and causes death, but I do not want to give the pression that the Chinchorro were sic They appeared to eat a relatively high-p tein diet and to lead active, healthy liv As one of my younger associates not holding up a skull of a middle-aged m the mummy's teeth were in much bet condition than his own. In later cultur when irrigation agriculture came to valley, Indians ate more carbohydra and less protein. And the teeth of th later Indians have many more caviti Unlike the Chinchorro, their success knew the agony of a toothache.

For perhaps 15,000 years, if not long the western coast of South America hundreds of miles north and south Arica has been dominated by inhospita desert. Only a few isolated groups of In ans, clustered around rare sources of fre water, managed to eke out a living. their narrow niche, these Indians lived d ferently and apart from the major grou and Indian civilizations of the Ande highlands and the continental interi Some preliminary genetic surveys in cate these Indians were the direct desce dants of earlier tribes that lived in the gion for many thousands of years. Su continuity is without precedent anywhe else in the world.

And the arid conditions that so shap their lives also preserved them in dea As our techniques of analysis improve, will learn more about the daily lives a conditions of these obscure Indians th we know about any other group in preh tory. After nearly 8,000 years of silenc the Chinchorro are beginning to tell the story, and we have much to learn abo them—and ourselves.

Mount Magazine, Arkansas

Robert H. Mohlenbrock

t 2,823 feet, Mount Magazine is Ar-sas' highest mountain, towering above broad Arkansas Valley. Its size, isola-, and outline—which early French ters thought resembled a *magasin* n, or storehouse)—have attracted nat-ists to this day. The plateaulike sum-located in Ozark National Forest in southern Ozarks, is about seven miles , east to west, and less than one mile ss. Lining the north side of the moun-are sandstone cliffs that overlook ely wooded ravines more than one sand feet below. E.J. Palmer, a bota-from Harvard's Arnold Arboretum, mented in 1927, "Nowhere else in this sually picturesque part of America e I seen anything that approaches unt Magazine] for variety, beauty, fine views."

he north rim is dense with shagbark ory, red oak, chestnut oak, basswood, sugar maple. A trail from Cameron f, the most prominent cliff, leads over edge of the mountain to a broad ledge, bench, where some of the United es' largest specimens of black walnut, e oak, red oak, sour gum, and white are found. What lured me to the ntain for a visit in late May, however, a number of rare plants that live on e north-facing bluffs. I needed to take a few steps toward the rim from the ntaintop parking area at Brown ngs to notice a plant with purple flow-the Ozark spiderwort, one of four spi-vort species that have evolved in isola-in the ancient Ozark Mountains.

s I proceeded down toward the first ch, I passed two kinds of trees that the Fish and Wildlife Service is consider-isting as endangered species. One was Ozark chinquapin, a close relative of majestic American chestnut, which is rently affected by the same chestnut nt that has devastated most American tnuts in the country. The other tree, se foot-long clusters of flowers hung efully from slender branchlets, was the smooth-trunked yellowwood. The future of this member of the pea family is in jeopardy because of its susceptibility to wood-rotting fungi.

Two ferns growing along the shaded north face of the bluffs also attracted my attention. Hay-scented fern, with four-foot fronds, looks like a tropical species but is truly a plant of temperate climates. In Arkansas it is found only on Mount Magazine and one other cliff. A more unexpected find is the much smaller Rocky Mountain woodsia fern. Mount Magazine is the only place it grows between the Appalachian Mountains to the east and the Rockies to the west. The population in west-central Arkansas may be left over from ages ago when this delicate-looking fern had a more continuous range.

But the most enigmatic plant to me was the maple-leaved oak, a small, shrublike tree that I had wanted to see ever since I had learned of its existence a few years earlier. Palmer, who discovered this oak along the north rim of Mount Magazine in 1925, had never before encountered it, and it still has not been found anywhere else. Because some of the leaves of this oak reminded Palmer of the leaves of the sugar maple, he coined the common name maple-leaved oak. The choice of a scientific name was not so easy, however. Was the plant an oak species that had evolved only on Mount Magazine? A hybrid offspring of two other oak species that lived in the area? Or a form of another species that developed odd-looking leaves because of the local habitat?

Palmer wanted to describe the maple-leaved oak as a new species, and had he found it in similar habitats on other Arkansas or Missouri mountains, he probably would have done so in an instant. But he hesitated to because the tree grew only on one mountain, and it was an oak. Botanists name new species of hawthorn, blackberry, or milk vetch at the drop of a hat. But oaks have the reputation of being highly variable and even "promiscuous," when two different species cross to form a hybrid. A new oak is rarely named unless there is nearly irrefutable evidence of major physical distinctions, such as unique acorns. (The acorns of the maple-leaved oak, incidentally, are viable, unlike the seeds of most plant hybrids. The young

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The Ozark spiderwort

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Mount Magazine

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plants they produce have leaves that resemble those of the adult plants.)

Palmer ruled out the possibility that the maple-leaved oak was a genetic freak because dozens of the plants lived on the rim of the mountain. He also found it difficult to imagine that any two of the other kinds of oaks then living on or near the mountain could have hybrid offspring with leaves like those of the maple-leaved oak. Palmer eventually decided, without experimental evidence, that he was dealing with an upland variant of the Shumard oak, a large tree found in the Arkansas Valley. He called it *Quercus shumardii* var. *acerifolia*, or the Shumard oak with maplelike leaves.

I do most of my botanical studies in southern Illinois, where the Shumard oak is a common forest tree. My first impression of the maple-leaved oak was that it had little in common with the Shumard. The habitat was wrong, the growth form was stunted, and the leaves, acorns, and buds were not really similar. Based on my own observations, I felt the maple-leaved oak was a distinct species.

There is one bit of research that can be done to try to unravel this oak's identity (and I am in the process of doing it). Nearly a decade ago, James Hardin and Paul Thomson, working independently at North Carolina State University and Southern Illinois University, respectively, discovered that each species of oak in eas ern North America has distinctive hai on its leaves. As seen through an electr microscope, some hairs are one-celle others multicellular; some are branche others unbranched; some are perched or pedestal-like stalk, others not. Interes ingly, a hybrid between two different oa has hairs from each of the parents. Wh the hairs on the leaves of the maple-leave oak are investigated with an electron m croscope, we should learn whether th match those of the Shumard or of a oaks in the area that might be the paren of a hybrid—or whether they are distin from all other oaks.

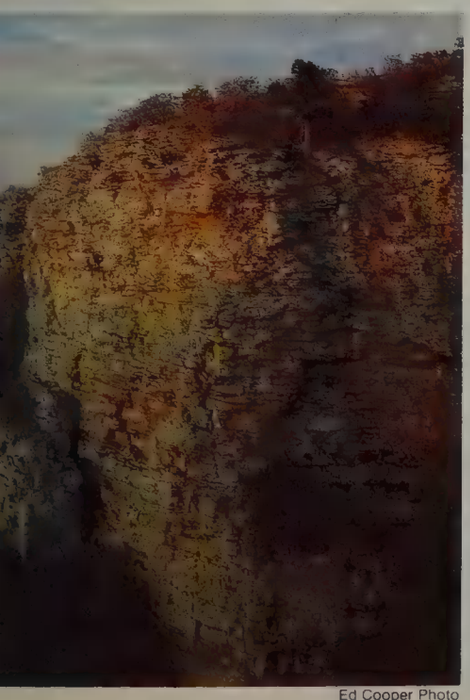
The vegetation and scenery of the nor face of Mount Magazine would be enoug to please most naturalists, but the mou tain offers more. Less than a mile awa across the flat summit, the south rim the mountain presents an entirely diffe

Mount Magazine's northern bluffs

t habitat. The arid conditions on the uthern face result in gnarled and unted trees. The post oaks that grow in e thin, parched, sandy soil are between 0 and 200 years old but stand less than ty feet tall, or two-thirds the normal ight. Where moisture is inadequate for ees, prairie grasses and wildflowers take er. The bluffs of the south rim are irreg-ar in outline and often form series of air-step ledges, where thick-stemmed ickly pear cactuses are able to survive oughty conditions by storing up large antities of water.

Near the western end of the flat-topped mmit, a scattering of wet pockets have en filled in by growths of sphagnum oss. These boggy depressions are ought to be left over from an ancient ne when the sea covered the entire area. s the ocean finally receded to its present sition, most of the coastal plain vegeta-n retreated with it. But the small bogs the summit of Mount Magazine have mained through the millennia, and sev-al of the plants that live there are coastal ain species. The yellow fringed orchid d the brilliant blue-flowered bottle gen-n are the most spectacular, but the rar-of all the plants on Mount Magazine is e inconspicuous dwarf pipewort, whose rrow, two-inch long leaves are barely ertopped by minute spherical gray wer clusters. Found only a half dozen nes, in western Arkansas, Oklahoma, d Texas, this flower is a candidate for deral listing as an endangered species.

his Land" highlights the biological enomena of the 153 U.S. national for-s. Robert H. Mohlenbrock is distin-ished professor of botany at Southern inois University at Carbondale.



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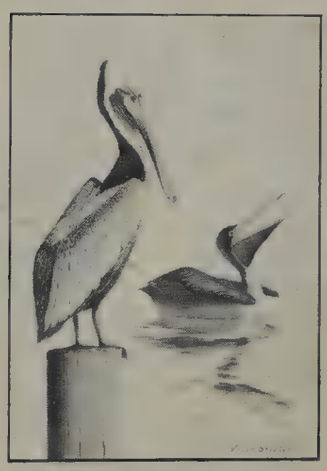

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Street Kids

by Brian Sutton-Smith

Children of the City paints a vivid picture of child life in American city streets between 1900 and 1920. Children are seen as laborers, hustlers, newsies, junkers, scavengers, and petty thieves, as "little mothers" watching over younger siblings, and as battlers for their own spending money. They are seen at play, and they are seen taking part in unions and strikes and defending themselves from the reformers who would coop them up in schools and playgrounds. More than sixty black-and-white photographs accompany the text and convey the atmosphere of the time with great power.

The descriptive material alone would have been sufficient for a book, but David Nasaw, who teaches history at City University of New York, injects a social and historical analysis as well. He contends that the early twentieth-century city was a city of immigrant strangers. Since most of its inhabitants had been born or raised elsewhere, only the children were really at home; and it was they who became the new Americans. They learned that if you could raise money, ever so little, leisure time could be a constant round of excitement. Unlike their rural forebears, who lived in a slower and less colorful world, these children were forced out into the street, with its crowds of children to play with as well as myriad spectacles and entertainments. There were subways, streetcars, skyscrapers, lobster palaces, vaudeville palaces, movie palaces, department stores, bridges, ferries, nickelodeons. It was these children, Nasaw argues, who grew up to become the consumer generation of subsequent American culture. They were the first to discover the purchase of goods and the purchase of leisure as a compensation for the miserable conditions of living and working. Put this way, what Nasaw gives us is only a rather dismal, and somewhat deterministic, story of the transformation of sober immigrants into leisure-hungry consumers.

But Nasaw has another and more romantic story to tell. It is about the sheer vitality of these city-street children, a vitality that transcends the miserable conditions of their lives, the overcrowding, the lack of privacy, the multistory tenements, the lack of ventilation, the stench from excrement, the darkness, the rats, the disease. Those "who portray the working-class immigrants as helpless, hopeless uprooted victims have misread the historical record. . . . The children of the city did not wither and die in the urban air but were able to carve out a social space of their own . . . the street made the children and the children made the street."

Literally hundreds of children played in the same side streets, and they formed quickly into gangs to protect their turf and their activities from other children, from adults, and in particular, from policemen. The cops were sworn enemies. Most of th

Roxbury, Massachusetts, August 1912

CHILDREN OF THE CITY: AT WORK AND AT PLAY, by David Nasaw. *Anchor Press/Doubleday, $18.95; 244pp., illus.*

---

ild arrests were for begging, bonfires, hting, jumping on streetcars, kicking er garbage cans, pitching pennies, loi- ing, throwing stones at lights, and so on. ambling, the most common cause for ar- st, was just another street game. As one server said, "The streets educated with al precision. The classrooms did not." Nasaw entirely ignores three books out children's play in this same histori- l period—*Play and Playthings,* by Ber- rd Mergen (Greenwood Press), *Mus- s and Morals,* by Dominick Cavallo

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(University of Pennsylvania Press), and *Choosing Sides,* by Cary Goodman (Schocken)—probably because these works chronicle the efforts of the play theorists and reformers to save children from what were seen as the abominable conditions of their lives. As Nasaw says, "The reformers' first priority was to remove these children from the contaminating effect of life on the city streets." But *Children of the City* portrays the reformers as almost complete failures. Children valued their own turf too much to go to the clubs or playgrounds. They might have dropped in out of curiosity, but they would seldom stay. The figures for playground attendance then were about the same as those today; only about 5 percent of a child's playtime is spent at such places.

Interestingly, most modern academic play theory is derived more from what children do in nurseries, playrooms, laboratories, and clinics than from what goes on in their habitats in the countryside or on the city street. *Children of the City* challenges the relevance of play theory. What we learn in this book sounds more like the barnyard play of a Rabelais than it sounds like the play described by a Piaget or a Freud.

But Nasaw's book is mainly about the life of children as workers, not as players. Most working-class families of the day could not live on the income of the primary wage earner. Between 1900 and 1920, child labor kept working-class families solvent and together, even as children were being steadily driven out of the work force by immigrant adults and by child labor legislation. What did persist was afterschool work. Most of Nasaw's book is about the part-time selling of newspapers and shining of shoes by children until they were finally forced out of even this type of work by adults. But there were also flowers to sell, errands to be run (before telephones), and lace and candy to be peddled. If a child could mimic dialects or sing, customers were more likely to buy. Older children managed groups of younger hustlers who were cute enough to sell papers on their looks alone.

Hundreds of thousands of childen who grew up in America in the first decades of this century sold newspapers. Circulation managers fought with one another to build up their stocks of children. Some estimates are that as much as 15 percent of the ten- to thirteen-year-old age group of city boys were involved. And in the meantime, these children learned that morality didn't exist in the workplace. Their Horatio Alger stories involved deceit, the stealing of tips, shameless soliciting, hustling the supposed last paper, and begging for tips—all of which Nasaw sees as having been great "fun" for those involved.

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Street gang, Springfield, Massachusetts, 1916

Many other children went into "junking" (salvaging) for wood, ice, iron, or coal on the railroad tracks, for old clothing, for furniture and machine parts, for bones, rags, bottles in alleys, for faucets and lead pipes in vacant houses, for overripe fruit, rotten meat, and other food at the produce markets. "American cities were the waste capitals of the world," writes Nasaw. Children collected junk like seagulls on the garbage dumps of the day. Junk was a necessary ingredient of survival.

The streets were usually regarded as off limits for girls, though not entirely so, for many girls were street traders along with their brothers. Legislation that regulated street trading often barred girls from th streets until sixteen years of age—boy were allowed on at ten—and elder siste were typically employed in raising your ger babies. Every increase in the mother workload (taking in washing, boarder homework for jobbers) meant an increas in the workload of young girls, but unlik their brothers, they did not get paid an therefore could not withhold or hide som of their earnings for their own personal en joyment. They could not experience th nickelodeons, the penny arcades, Bijou Pictoriums, and Theatoriums to anywher near the same extent that their brothe did. Commentators of the day noted tha lower-class children made up the majo part of the crowds in the cheap entertain

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Child bootblack, New York City, 1910

nt centers. One of Nasaw's most inter-
ng chapters concerns the reformers'
uccessful attempts to get the police, or
one else, to enforce the legislation
ant to protect these children from such
ces and worse; from child abuse, seduc-
n, lewd posters, and white slavery. For
saw, the kids' "street smarts" were by
l large their best protection, and they
ded no more.

Finally, Nasaw describes the great
vsboy strikes, when boys sought to pro-
t their percentage of the sale and
ght efforts by big companies to in-
ase profits by lowering the margin. In
early years the boys won handily, but
r, as they were replaced by adult ven-
s and adult-controlled distribution sys-
ns, they were defeated.

All of this makes for an exciting story
l supports Nasaw's more general con-
sion that the period between 1900 and
20 was indeed a very special interval. It
rked the transition from the predomi-
ntly rural life of the prior century to a
urban one that was to increasingly con-
n children. Relics of rural pastimes sur-
ed along with emerging forms of com-
rcial stimulation and crowds of
ailable players, effective adult organi-
ion of all phases of a child's life was still
come.

Unfortunately (to this reviewer at
st), the author returns at the end of his
k to the broad and deterministic social
alyses with which he began:

> e street bred a gritty self-reliance in its
> ldren. . . . Only in the entertainment in-
> stries which grew up with the children
> uld [they] achieve an influence that was
> h profound and predominant . . . they
> posed their childhood moralities on the
> een . . . the gangster films are films
> out the city . . . the gangsters represent in
> ggerated, almost mythologized form the
> ldren of the city . . . the street traders
> l performers energy and exuberance be-
> yed an anxiety that anything less than to-
> effort would not suffice . . . [they were]
> rd hit by the Great Depression but not
> rd enough to destroy the faith that had
> en built on the streets of the city . . . the
> th in capitalism and the American politi-
> system . . . [they] suffered from tunnel
> ion through their lifetimes . . . they could
> accept the claim that America was not
> d had not always been the land of oppor-
> nity and beacon for the freedom for the
> or and oppressed . . . [their optimism]
> remains with us as a barrier to the re-
> nking and restructuring that must take
> ce if we are to proceed toward a more
> oductive and a more just future.

While one can concede some links be-
een the small-scale hedonism of these
st city dwellers and their subsequent

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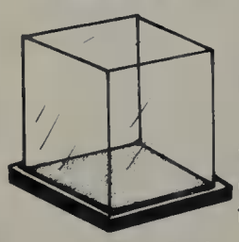

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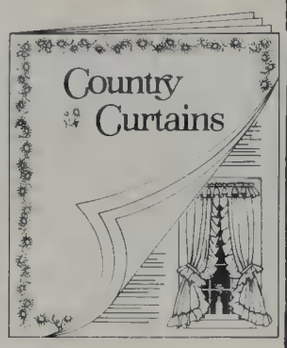

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*ian Sutton-Smith is a professor of edu-
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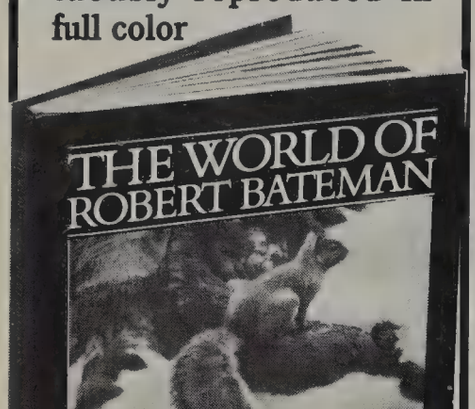

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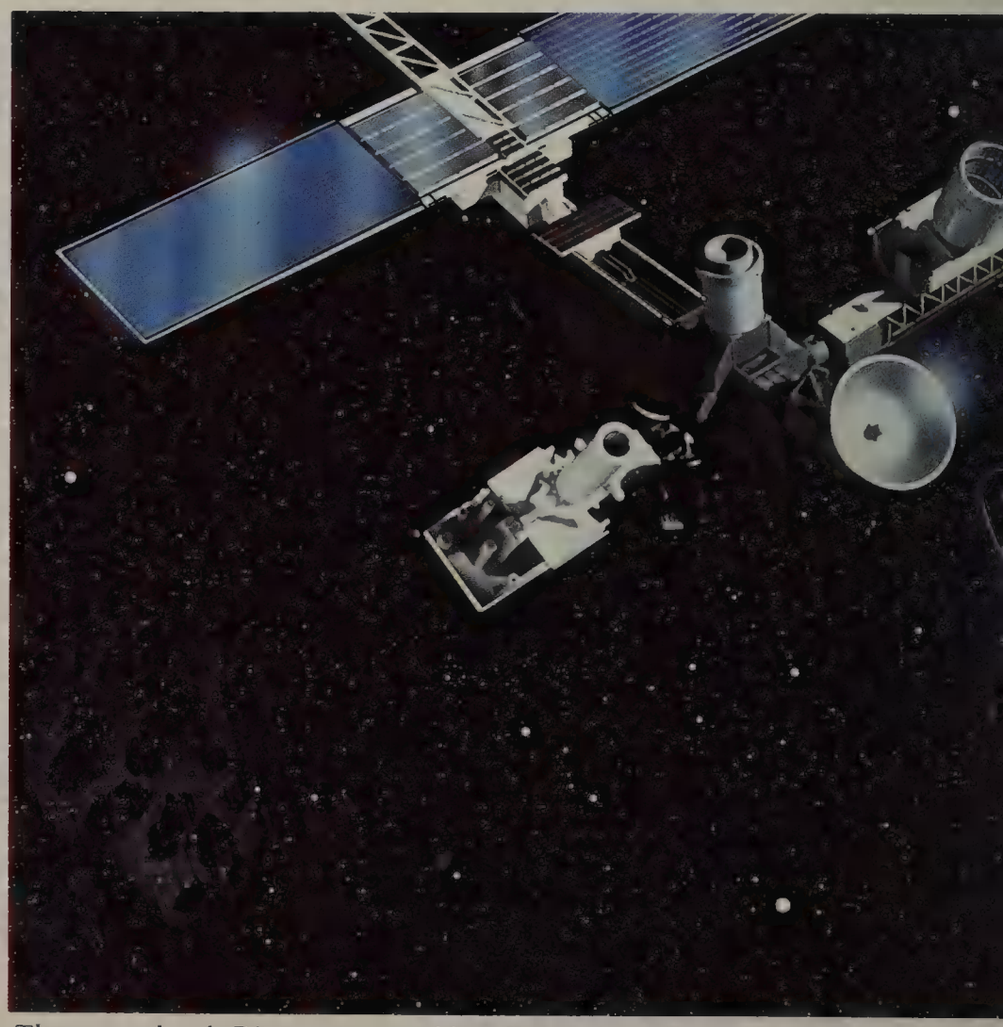
A Domeful of Stars

The original nineteenth-century plan for the American Museum of Natural History called for a soaring, Romanesque-revival tower rising from the center of the Museum's complex of buildings. The interior of this tower was to contain (appropriately enough) a vast Hall of the Heavens. But the great spire was never built, and it wasn't until 1935—some sixty years later—that the true "hall of the heavens" opened: the Hayden Planetarium.

An early article about the Planetarium described the spectacle presented by the first Zeiss projector. When the lights went down and the stars appeared, the commentator wrote, an "involuntary gasp" arose from the audience. The Zeiss projector, a marvel of German engineering, duplicated on the Planetarium dome thousands of stars exactly as they wou appear in the night sky. The illusion w nearly perfect. At the time, Planetariu Sky Shows consisted of a lecturer talki about the various stars, planets, and co stellations. The only "special effect" w the little flashlight pointer the lectu used to identify various stars.

Today, as the Planetarium celebrat its fiftieth anniversary, much of that h changed. Not only is the universe a mu vaster place than earlier thought, but it populated with complex phenomena such as black holes and exploding gala ies—that cannot be simulated with t Zeiss projector alone. And no longer can mere domeful of stars satisfy an audien raised on television and Lucasfilms' sp cial effects. Today, one recent Sky Sho



The space shuttle Discovery *assembling Star Lab, as depicted in a recent Sky Sho*

the Hayden Planetarium included the mulation of a supernova and expanding ebula, a glowing comet coma, rockets asting off, and a panoramic view of the rface of the sun with a vast solar flare cing across the sky. Images, sound, and ecial effects filled the Planetarium ome—which is forty-eight feet high, sev-nty-five feet in diameter—for the dura-on of the forty-minute show.

The creation of a modern Sky Show at he Hayden Planetarium takes several nonths and involves model building, art-ork, special photography, four comput-rs, sound and music synthesis, complex ptical effects, several hundred custom-uilt projectors, specially designed elec-onic circuitry, and, of course, the $2 mil-on Zeiss VI Star Projector—the sixth-

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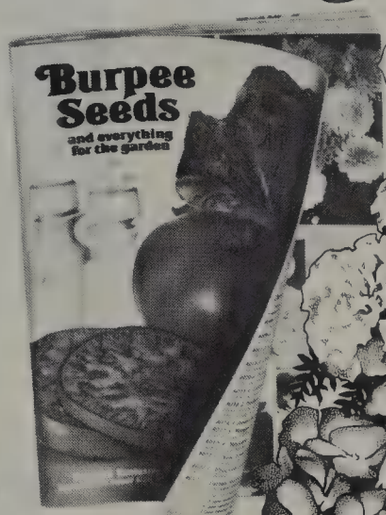

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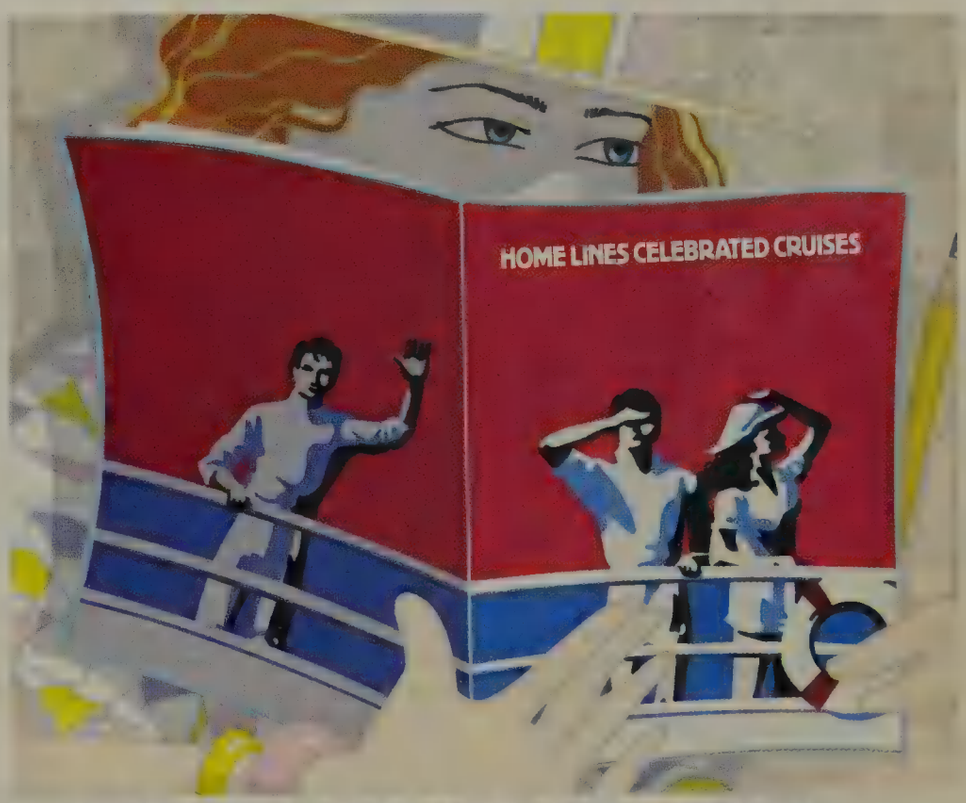

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Today, scripts narrated by Charlton Heston, Leonard Nimoy, William Shatner, and others have replaced the live lecturer. William A. Gutsch, Jr., the Planetarium's chairman, is a professional Sky Show writer (in addition to holding a Ph.D. in science education) and creates most of the scripts himself. "The shows are written," he says, "with special effects in mind. We want to create an environment in the dome. We're right there, floating in space. Or we're standing on the surface of Io next to a volcanic eruption. Or we're peering into a black hole."

The Planetarium is commemorating its fiftieth anniversary with Hayden: The Golden Years. *Narrated by Charlton Heston, this Sky Show looks at what we have learned about the universe over the last fifty years. The Planetarium is also presenting* Halley's Comet: Once in a Lifetime, *narrated by William Shatner. Both shows are offered as a double feature. For more information about the Planetarium call (212) 873-8828.*

Black holes and other exotic environments are created in the Planetarium's basement. When Gutsch has finished a

A detail from Helmut Wimmer's depiction of a black hole

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draft of the script, he sits down with a
of technicians and other staff mem-
and they discuss and compile a list of
fred effects. Some of these may have
invented for earlier shows, while oth-
ave to be dreamed up. The list of ef-
for one brief segment, written in
etariumese, might read as follows:

Epidyascope asteroid, add rotating
arth chord
witch on all dome strobes
Blink fade to burned-out forest pan-
rama and all sky clouds and brute
orce ring of fire

his scenario calls for a huge, pitted as-
id plunging toward the earth, followed
brilliant flash of light and a deafening
. Then the scene cuts to a panorama
nd the perimeter of the dome; the
er sees a burned-out forest, flickering
es, and clouds. This entire sequence
ffects might take all of fifteen sec-
s—and is accomplished entirely with-
the use of film or video. The produc-
team's job is to translate a scenario
as this into realistic images on the
e. Each member of the team is re-
nsible for certain kinds of effects and
ork according to his or her specialty.
he Planetarium's chief artist, Helmut
nmer, is a vigorous German-American
is considered the dean of planetarium
sts. Wimmer started his career sculpt-
and making architectural models in
many before World War II. Six days
r the war ended, Wimmer was cap-
ed by the Soviets and transported
ough labor camps in Czechoslovakia,
ngary, Romania, and finally Russia. A
del he built of one of the camps at-
cted the attention of Soviet officials,
recognized his talent and assigned
to work on the restoration of an elabo-
eighteenth-century baroque castle
later a theater complex. After his re-
se in 1949, he returned to Germany and
years later emigrated to the United
tes. He has worked for the Planetar-
ever since, painting everything from
loding galaxies to alien landscapes. He
the first artist to depict a black hole,
cially commissioned for a 1971 *Phys-
Today* cover.

Wimmer's paintings are the basis for
galaxies, nebulae, wraparound pan-
mas, and other scenes on the Sky Show
ne. Combining airbrush and sculptural
hniques, Wimmer creates an uncanny
ee-dimensional illusion. He usually
nts on a black piece of cardboard just
r a foot square. The completed paint-
s are photographed with 35-mm color
le film for projection on the dome.
Some of the most dramatic scenes in the Sky Show are of spacecraft blasting off or floating in orbit. The models of these spacecraft—as intricate and fantastic as any used in the movie *Star Wars*—are created by Brian Sullivan. In addition to his projects at the Planetarium, Sullivan builds spacecraft models for NASA and the European Space Agency, and his work has appeared in *Time*, *Omni*, and on six *Discover* magazine covers.

"As a kid," Sullivan says, "I was just nuts about models. I wanted to be a train engineer until I saw the movie *2001*." Sullivan's office in the Planetarium's basement is cluttered with his foot-long models, from several replicas of the space shuttle to complex and fanciful visions of orbiting space stations and starships.

Sullivan is forever on the lookout for material for his models. He has used plastic parts from model kits, cut-up Tupperware, light bulbs, and miscellaneous junk. One of his orbiting space stations started as a plastic ice cream lid, which he embellished with PT-109 model torpedoes and finished off with parts of model tanks. A replica of the Soviet comet probe Vega started with a light bulb. "The only difference between us and Lucasfilms," says Sullivan, "is a $25 million budget." Most

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of his models cost less than $10 to buil
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ber optics to simulate windows on a spac
station, Sullivan paints the windows on
plastic overlay or shines dots of light ont
the model with a projector. In the latte
case, a double-exposed photograph, on
exposure shot in the dark and the othe
with a flash, will give a remarkably reali
tic result. When a model is finished, it
photographed in black and white, and th
photo is airbrushed and painted in colo
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to be rotated and the image moved acros
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optical effects add rockets and flame
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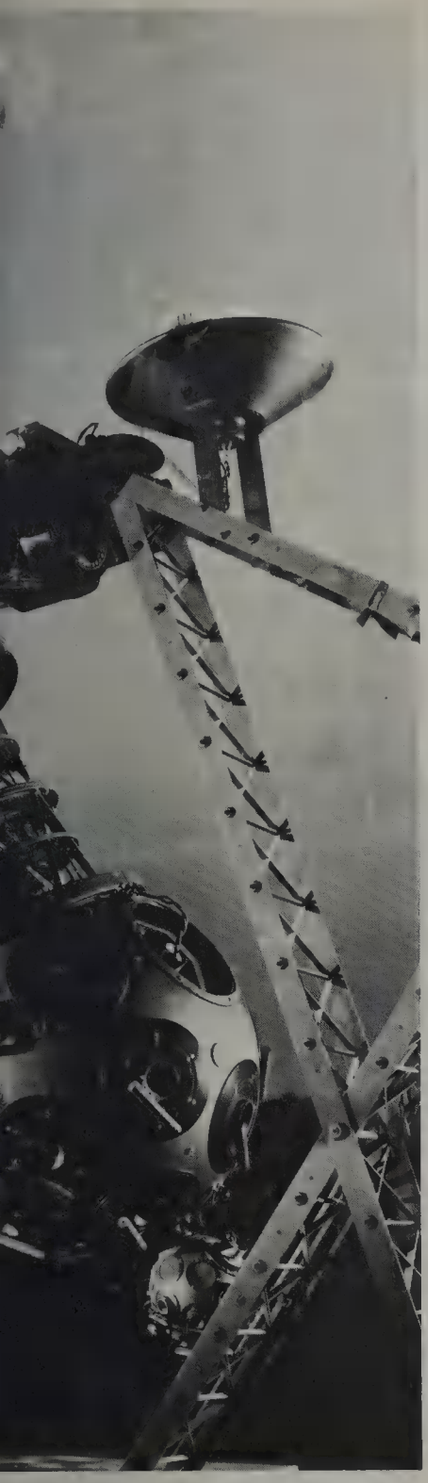

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al lenses, and tiny motors, chief tech-
n Joe Maddi and his crew translate
iny images on the slides into full-
n landscapes and special effects. The
oling asteroid mentioned earlier is
lated by an epidyascope projector,
h can hold a minute three-dimen-
l object in the space that normally
es the slide. Maddi then installs a tiny
el of an asteroid, rotated by invisible
s, inside the projector. The result,
n projected on to the Planetarium
e, is a huge, pitted asteroid whirling in
e. To send the asteroid spinning
ss the dome, Maddi bounces the im-
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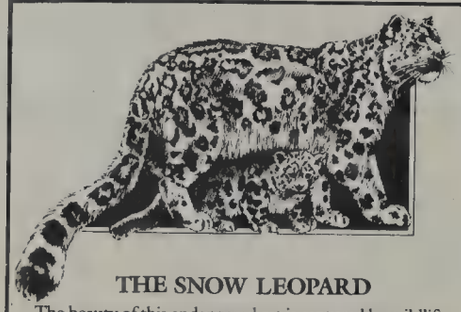
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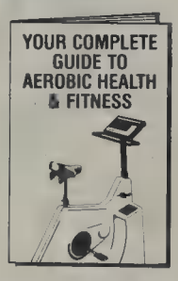

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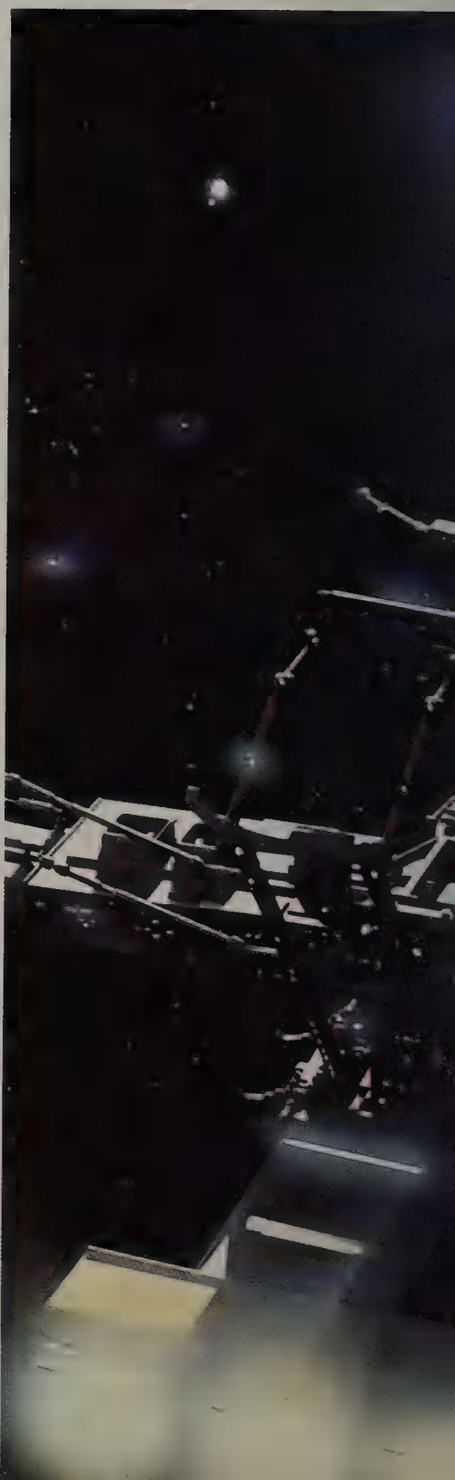
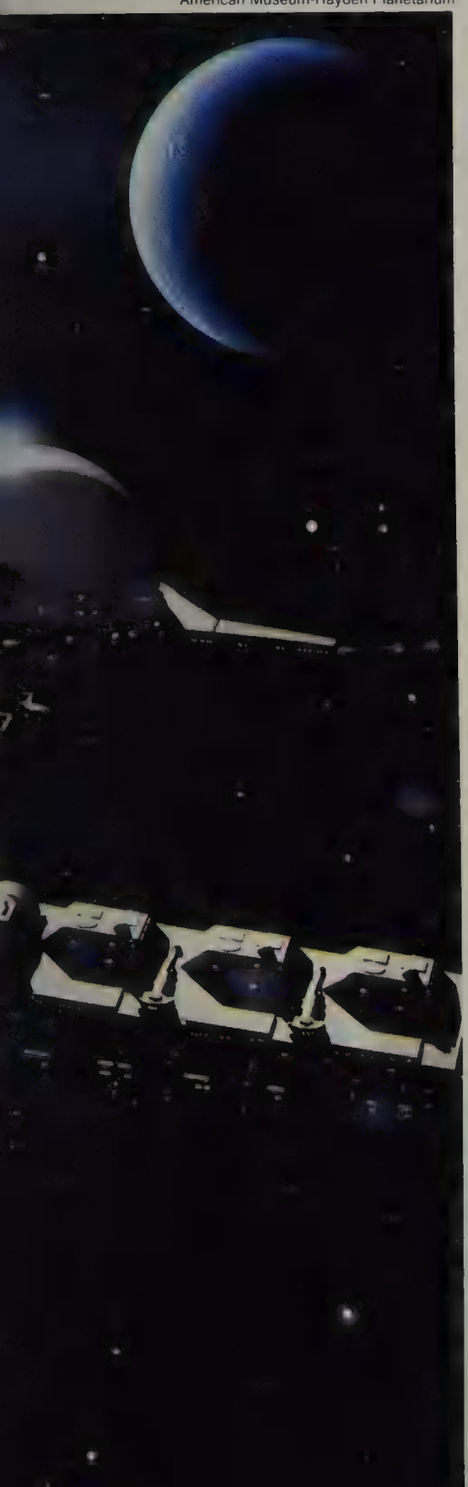
such phenomena as supernovae, rot planets, snow blizzards, expanding lae, solar flares, auroras, meteors, pling comet coma, and explosions sorts—about 200 special effects in al matter what the script calls for, M and his assistant, Joe Doti, can us build some sort of Rube Goldberg traption to fit it. Their current pr calls for creating a "globular cluster chine" by modifying several projecto that they can rotate slides covered starlike dots. A special lens, called a shooter, duplicates the star images times. The audience experiences th fect of being in the heart of a glob cluster.

Brian Sullivan's vision of a starship approaching Earth orbit



About 200 of these projectors, custom
it by Maddi and his associates, line the
netarium's perimeter, and a single spe-
effect or environment can require up
30 projectors operating *simulta-*
usly. One Sky Show can easily run
ough 1,000 or more slides. That comes
an average of one slide every two sec-
ls for the forty-minute show.
Each special effect is accompanied by
thesized sound effects, music, and nar-
ion. One of the most complicated parts
he Sky Show is timing the effects to ap-
r at exactly the right time. "In the old
s," Maddi explained, "they used to
e a guy turning knobs and pushing but-
s. But there's only so much that a man
ld do." Now the task is performed by a
r of Eagle II computers, with a third
ving as a backup. The producer of the
w, Larry Brown, writes a program to

American Museum-Hayden Planetarium



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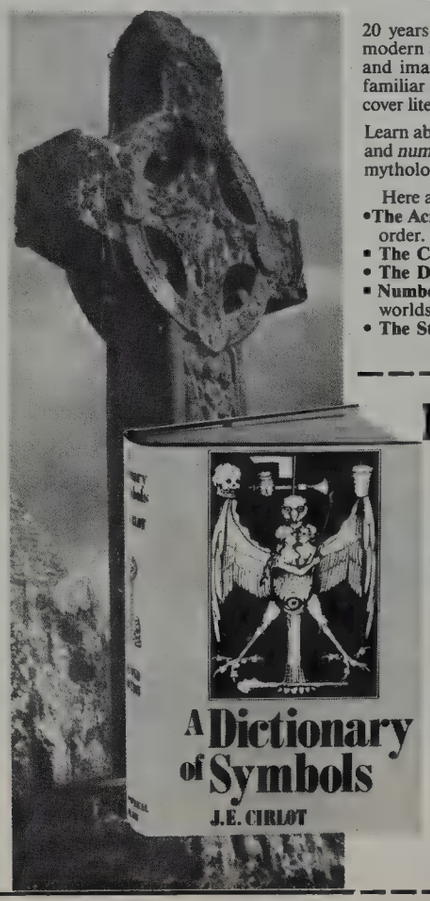

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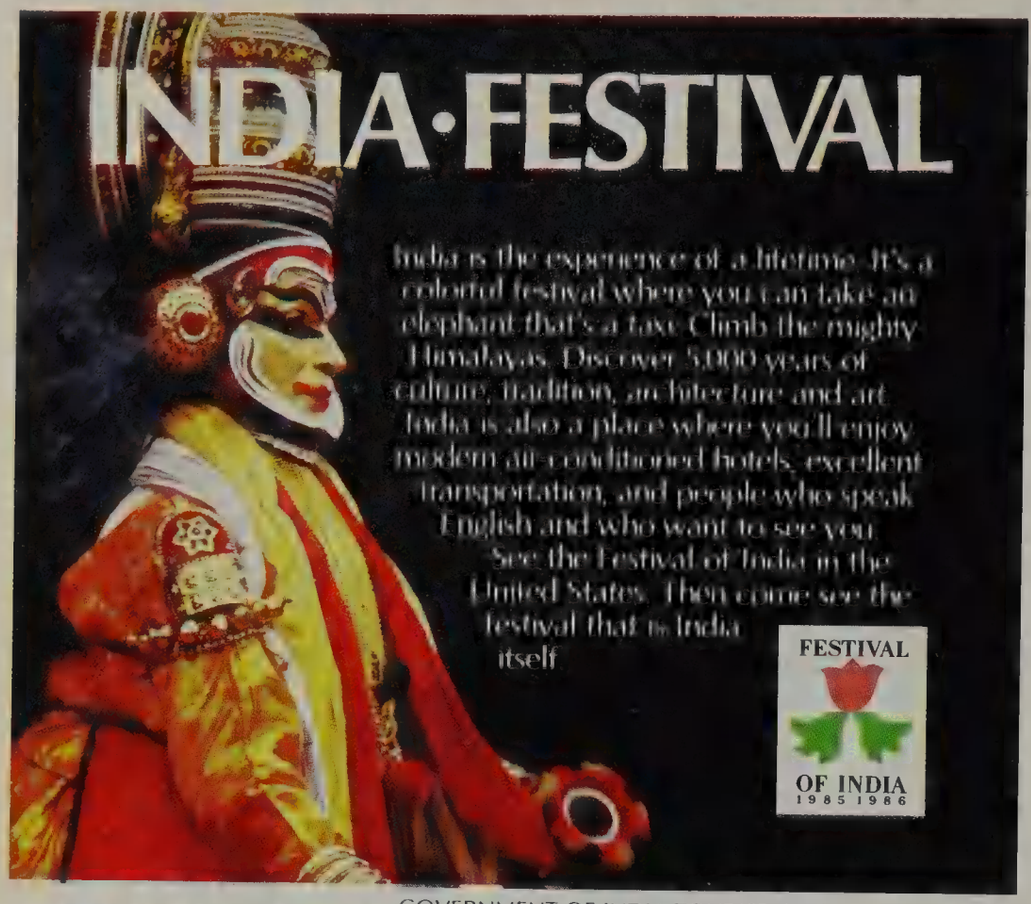
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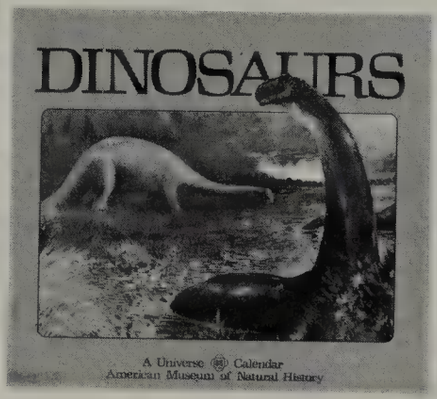

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control the show. The computer instru tions are recorded on the same magne tape that holds the sound track, so that t computers send their commands to all t equipment at precisely the right mome

When the system was first designed, electronic device existed that would co nect the Eagle computer to a special fects projector. A computer can only se out coded instructions, which obvious the motor on a projector could not unde stand. (A commercial company does s an interface—called a Dove—for caro sel projectors, which are also used in t show.) However, electronics technici Kai Eng still had to design and hand bui yet another device, which he named t pigeon in keeping with the ornithologic nomenclature of the system. Eng a Julio Marrero, another electronics techn cian, have now built some 200 of these i terfaces, one for each projector. Now t only button that needs to be pushed durin a Sky Show is the one that turns on t computers. (The Zeiss, however, h never been computerized, as it is easi controlled by a single operator.) The mu sic and sound effects are almost all orig nal and synthesized for each Sky Show.

At the American Museum

Museum Lecture Series

The Education Department's fall lec ture series begins in October. Among th lectures are *Sumer: Roots of Civilizatio* about the architecture, tombs, and socia life of this ancient civilization; *Jewis Communities in History*, about Jewis communities worldwide, from Ethiopia t China; *Films from the Museum's Ar chives*, featuring rare anthropological an expedition films from 1908 on; and others For information, call (212) 873-7507.

People Center

The People Center is celebrating India with a series of programs in October an November. The events include music dances, storytelling, and slide lectures o many aspects of Indian life and art. These free programs take place in the People Center each weekend from 1:00 to 4:3 P.M., and visitors are encouraged to drop in at any time.

Halley's Comet

The October members' program, *Here Comes Halley's*, will focus on the comet's upcoming appearance. Stephen P Maran, *Natural History* columnist and senior staff scientist at NASA, will give a

roducing a forty-minute Sky Show cost about $100,000 to $200,000—e modest considering the special ef-s. The Planetarium produces three or Sky Shows per year, as well as a ber of special lectures and children's grams. "The Planetarium staff," says sch, "has become rather adept at ing magic on a tight budget. It just s cleverness and a little genius." The tement of a Sky Show, Gutsch feels, ws the viewers into the subject matter ends up teaching them more about as-omy than a fact-filled lecture. And sch makes sure that all special effects, dscapes, and models are as scientifi-y accurate as possible. When the audi-e looks down the throat of a black hole, image represents a visualization of latest knowledge of black holes—not artist's fantasy.

We're here to teach astronomy," tsch says, "and the best way to do that, ur opinion, is to be entertaining as well instructive. Besides, the universe has ome so complicated in the last fifty rs that we *have* to use special effects to w what these things look like."

Douglas J. Preston

e-illustrated lecture about comets, ex-ining what they are and what they can us about the origins of the solar sys-n. He will also discuss what we can ex-t to discover as Halley approaches rth. The program is $3 for members, $6 nonmembers, and takes place on ursday, October 17, at 7:30 P.M. in the ditorium. Advance registration is re-red; please call (212) 873-1327 for re information.

upuncture Symposium

On Wednesday, October 9, the *First ernational Symposium of Acupunc-re and Electrical Therapy* will be held the Museum. (Four other sessions will e place at the Penta Hotel.) At this eting, scientists and informed layper-ns will learn about the latest develop-nts in the field of acupuncture. The ogram is free to all Museum visitors. r additonal information, call (212) 873-00, ext. 559.

orkshops for Young People

The Education Department is offering wide range of programs for young peo-e this fall. Starting in October and No-mber, the workshops include *Through e Eyes of a Child*, an introduction to the useum for very young children; *In earch of Human Origins; Origami; Se-ets of the Sea; Native American Games d Crafts;* and many more. For informa-on and a brochure call (212) 873-7507.

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- ☐ **ANTHROPOLOGY TOUR TO MOROCCO:** March 21—April 5
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- ☐ **CHINA—The Ancient Silk Route:** Sept. 17—Oct. 10
- ☐ **ZAMBIA, ZIMBABWE AND BOTSWANA SAFARIS:** Sept. 12—28 or Sept. 26—Oct. 12
- ☐ **EAST AFRICAN SAFARI:** Sept. 25—Oct. 19
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Planets Go Their Way

by Thomas D. Nicholson

During October the planets are more or less in transition between the morning and the evening skies. Venus is still high enough and sufficiently bright to be conspicuous in the southeast during morning twilight. As the sun continues to move farther to the east of Mars in the sky, the planet becomes easier to see in the southeast just before sunup.

Among the evening stars, Mercury is just beginning its sunset sojourn. Consequently, it will remain very low in the west after sunset and will be extremely difficult to observe. The chances for viewing Mercury improve, however, in the first week of November. Saturn, in Libra, is ending its appearance in the evening sky.

During the early part of the month, Saturn may be glimpsed very low in the southwest just after sundown. By month's end it will be lost in the sun's glare. Only Jupiter, in Capricornus, adds spice to the evening sky; it outshines any star in the night sky and can be seen low in the southeast after sunset. The first-quarter moon will pass close to Jupiter on the 20th.

Events in the calendar below are given in local time unless otherwise indicated.

October 1: The harvest moon lingers on. Although nearly three days past full, the moon rises only about an hour later than when it was full (September 28). The two stars above it, alpha and beta Arietis, are in Aries.

October 2: Apogee moon (farthest from the earth) crosses into Taurus.

October 3: Jupiter takes up its easterly drift through Capricornus.

October 4: Venus and Mars rendezvous in eastern Leo. Venus, the bright planet, is low in the southeast this morning; Mars is much dimmer and close by to the left. After Venus passes Mars tonight, they return on the morning of the 6th, still close together, but in reverse order.

October 6–7: The moon rises after 10:00 P.M. in Gemini and reaches last-quarter phase just four minutes past midnight, EST.

October 10: The morning moon is i Leo, near the constellation's brighte star, Regulus.

October 12: The late crescent moo joins Venus and Mars, which continue t be close to each other, in the morning sk Venus and the slender moon are very a tractive. Mars is also there, to their righ but dim.

October 13: New moon, at 11:33 P.M EST, is just above Spica in Virgo.

October 14: Perigee moon occurs lat today, less than twenty-four hours afte last night's new moon, raising the range o the spring tides. Look for exceptionall high tides on the morning of the 15th.

October 15: The moon's disk, barel past new, slips across the face of Mercur to occult the planet over northern Asi and the Pacific.

October 16: The sliver of a crescen moon that may be visible after sundown i not quite three days old. Saturn is above i and to its right, but the sky may not b dark enough to see the moon before it sets

October 17: The moon is nea Scorpius's Antares tonight (below and t its right) but the lunar crescent is i Ophiuchus. It passes through this little known constellation along the zodiac fo nearly half a day.

October 18–19: Look for the moo among the stars of Sagittarius on both nights. The not quite first-quarter moo shouldn't be bright enough to hide the stars of the Teapot that identify the con stellation.

October 20: First-quarter moon, at 3:1 P.M., EST, moves from Sagittarius into Capricornus, where it will be after sunset

October 21: Dust left behind by Hal ley's comet when it passed through the so lar system long ago races toward us out of the comet's orbit each fall, appearing as a shower of meteors from the constellation Orion. The Orionids reach maximum this morning, when we may be able to see up to twenty-five meteors per hour. They often look bright because their particles are moving so swiftly.

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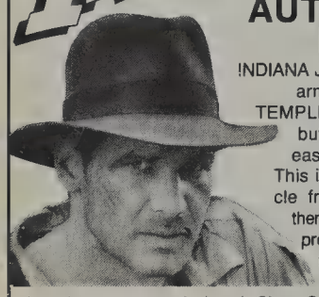

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October 21–22: The moon accompanies Jupiter as they move across the sky tonight, separating slowly, with the moon moving to the east of the planet.

October 23–25: The waxing gibbous moon grows fatter nightly and stays up later as it works its way eastward through Aquarius into Pisces by the 25th. On the nights of the 23d, 24th, and 25th, the Square of Pegasus is above the moon, the star Fomalhaut is below it on the 23d and Diphda, in Cetus, is below it on the 25th.

October 26–27: After passing briefly through Cetus, the moon returns to P these nights as it approaches full p Note how rapidly the brightness in th around it increases.

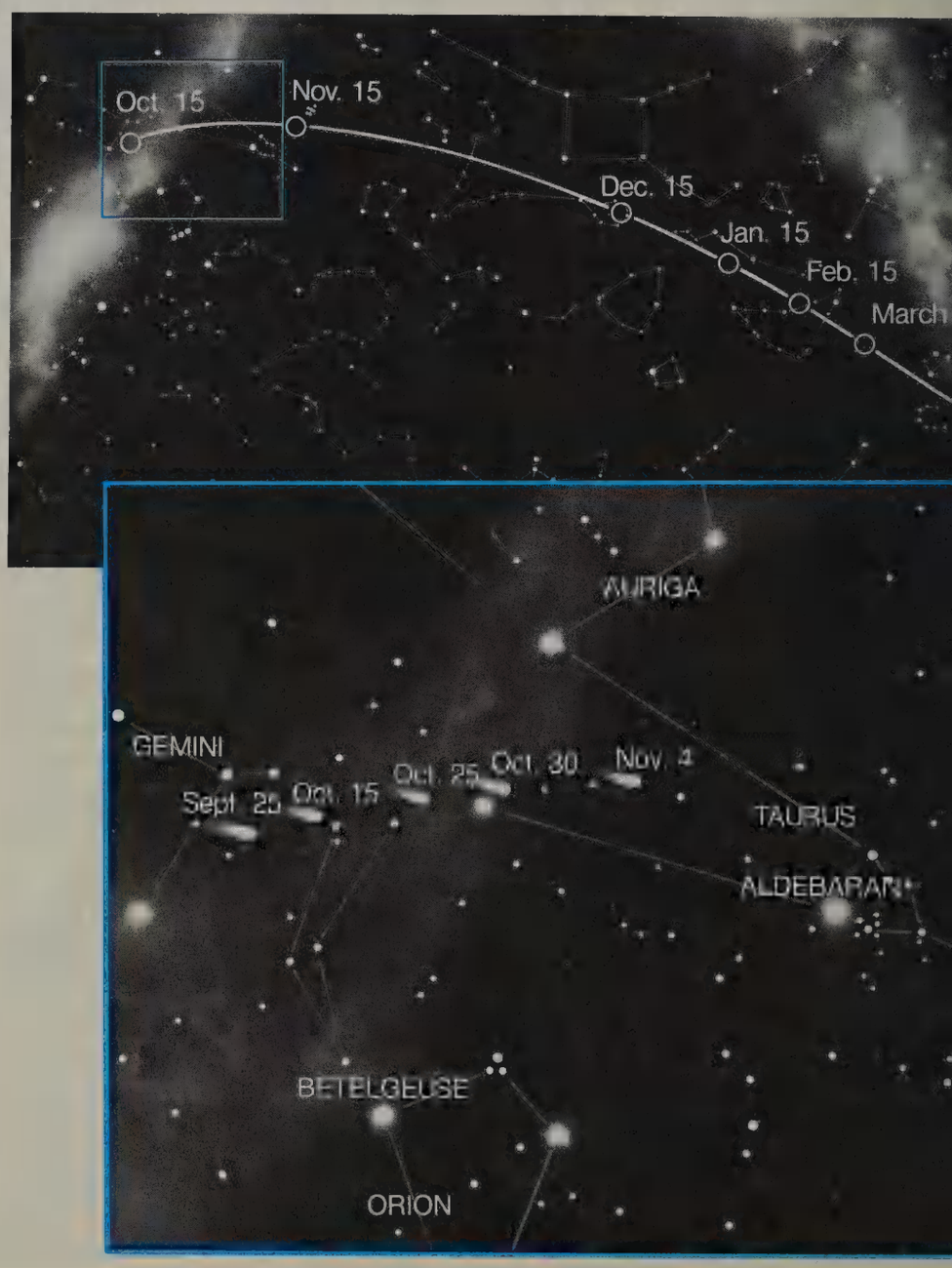
October 27: Communities using light time gain an hour when they a their clocks to standard time t (Clocks are set back one hour.)

October 28: Full moon (the hun moon) is at 12:38 P.M., when it is day over most of North America. But Alaska and parts of northwestern Ca sunrise has yet to occur, so the begin

Halley's Comeback

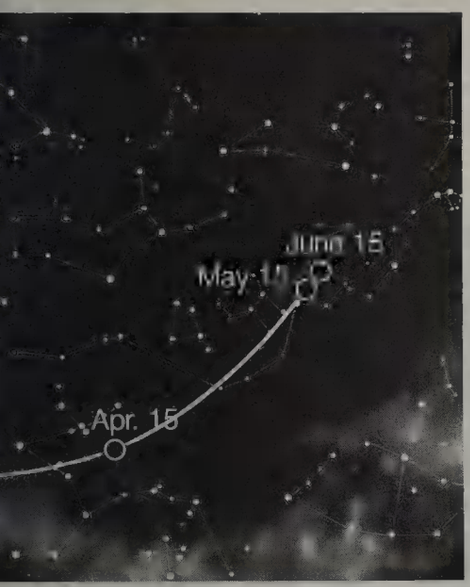
When comets are first discovered, they appear to be little more than faint hazy specks of light in astronomers' telescopes or on photographic plates. The only sign that they are not stars is that they move, slowly changing their positions amid the myriad of stars. This slight motion makes comets and their orbits identifiable.

Comets come of age, however, w they develop the two structures that tinguish them from other celestial jects—a coma and a tail. Halley's co already had a discernible coma last m and it should show the beginnings o dust tail this month. Toward the end o month, the comet should also bec



a total lunar eclipse can be seen there
ore the moon goes down. Elsewhere, in
Eastern Hemisphere where the moon
till up, it will be completely within the
th's shadow for just a few minutes dur-
this relatively shallow total eclipse.
October 29: Apogee moon again.
October 30: Mercury and Saturn are in
njunction but within a very short dis-
nce of the sun.
October 31: The moon ends the month
Taurus, not far from the constellation's
ddish star Aldebaran.

ght enough to be seen with binoculars.
The material that eventually becomes
e coma and the tail is in the comet all
ong, in the form of frozen gases and
pped dust. When a comet comes close
the sun, the outer gases evaporate, ex-
nd outward, and free the dust particles.
nlight reflected from the dust and the



Helmut Wimmer

The top diagram traces Halley's path
om left to right as it moves across the
y. The circles and dates indicate where
e comet will be on the fifteenth of each
onth from this October to June 1986,
hen it will have completed its journey
ound the sun. The comet will continue
fade from view, returning to the cold
id of interplanetary space.
The enlargement at left gives the exact
ites for the comet's positions as it passes
rough the stars of Taurus and Gemini.
his map will be updated each month to
t you know where Halley's comet will
ppear. Until mid-January 1986, at least
om the Northern Hemisphere, binocu-
rs or a telescope will be necessary to
ew the comet. Under a good dark, clear
y the comet may reach naked-eye visi-
lity by mid-January 1986.

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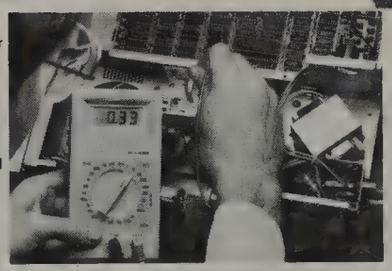

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fluorescence of the gases combine to cause the halolike coma to appear. Still later in the comet's race toward the sun, the material is swept away, the dust is diffused by the sunlight's pressure of radiation to form a sharply curving tail, and the ionized gases are deflected by the solar wind into a long, straight tail of fluorescing matter.

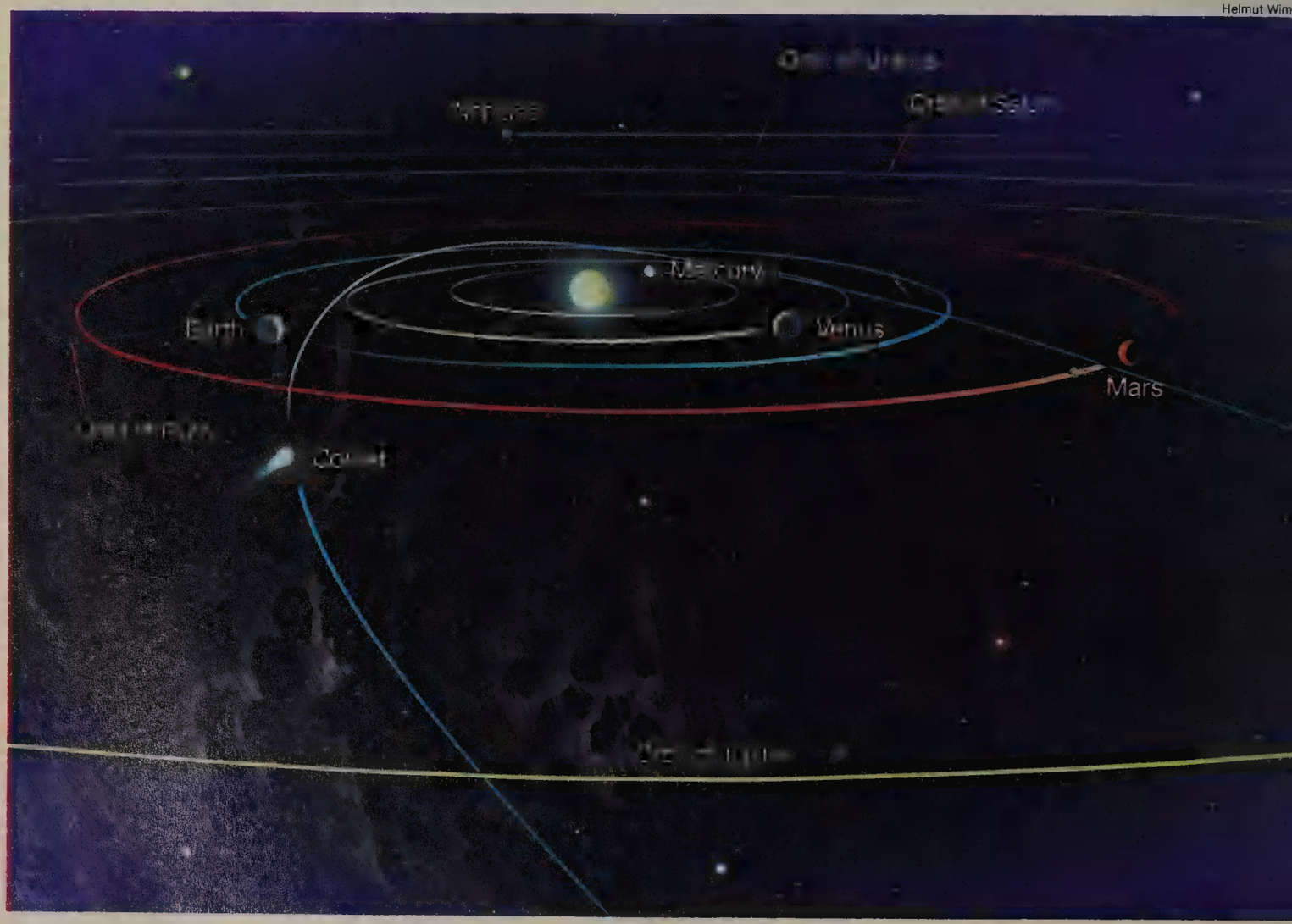
What can we expect of Comet Halley's coma and tail this time around? These structures vary widely from comet to comet, reflecting differences in the ratio and density of the gases and dust. A comet may also vary from one appearance to the next because on each time around, it presents different layers of matter to the sun and the old layers are blown away. Should the coma and tail be closely replicated from one solar pass to the next, their appearance would still depend on the comet's path relative to the earth. And even the best of tails palls when seen head-on from a great distance. Judging by its past appearances, Halley's comet should produce a spectacular coma and tail.

During the comet's last passage around the sun, its coma was estimated to be 40,000 miles or more in diameter. The tail developed more slowly before perihelion and reached its greatest length six to seven weeks later, when it grew to be about 50 million miles long, more than half the distance between the sun and the earth. That suggests that the longest tail during this trip may occur in March 1986, shortly before the comet's close approach to the earth on April 11.

Unfortunately, when Comet Halley's tail may be at its longest next spring, we will be looking at it virtually head-on, and it will be more than two and a half times farther away from the earth than it was in 1910 under the same circumstances. That doesn't bode well for the tail's appearance in our skies. Worse still for Northern Hemisphere viewers, the comet will be in the direction of Sagittarius and Scorpius in late March and early April. If you know the summer evening sky, you will realize that these constellations never rise very far above our southern horizon (see the July Sky Map). Neither will Halley's comet. We can expect it to be up in the dark sky for only about two hours or so in the early morning, with its tail preceding and towering above it. As we view those constellations and Halley's comet from more southerly latitudes, we will see all three earlier and higher in the night sky. Fr the southern parts of South America, A tralia, and New Zealand, however, comet will be visible all night long, wh explains why eager comet watchers migrate south late this coming winter a early spring.

Northern comet seekers get their t this fall, before perihelion, as Halle comet approaches and then passes opp tion from the sun in late November. Fr now through November 27 (the come closest approach to the earth before pe helion) and until mid-January (when comet moves too close to the sun to be se from the earth), we in the north have decided edge. True, the comet will pro bly not have much of a tail, but it will virtually as bright for us in January a will be in late March for those south of equator. By mid-October, Halley's com will have come to within 150 million mi of the earth and should brighten to ab magnitude 10, within range for a thr inch-aperture telescope. By the end of month, it brightens by another full mag tude, bringing it within reach of expe enced skywatchers with binoculars.

Helmut Wim



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The Way We Eat Now

Lacking a traditional cuisine, Americans are using ideas from a variety of national pasts

by Raymond Sokolov

In the fuggy heat of late spring this year, one thousand people in formal dress trooped down to New York's Rockefeller Plaza to eat the splashiest buffet dinner in gourmet memory. Each diner paid a minimum of $250 for the privilege of tasting food prepared by a dozen innovative chefs from around the country. The contributions, every last cent of them, went to City Meals On Wheels, a program sponsored by the New York City Department for the Aging that brings hot food to the housebound elderly. All in all, it made a dignified and appropriate wake for James Beard.

Beard had died, at age eighty-two, a few months before this memorial celebration, after years of intermittent illness and many decades as the uncrowned king of the American culinary world. This portly, sensual buddha of food had thrown his great influence behind City Meals On Wheels with the same generosity that had launched and fostered the careers of scores of people in the food field. Indeed, several of his more recent protégés had come to Rockefeller Plaza from their own newly famous restaurants to serve their specialties.

This food, much of it squarely in the center of what has been called American *nouvelle cuisine*, made a fitting tribute to Beard's crucial role in guiding and refining the nation's growing culinary sophistication. No one had done more to preserve traditional American food ideas, but no one had ever supported the creativity of young chefs with greater energy and intelligence than Beard.

The menu that night ran the gamut from the solidly old to the tremulously new. Larry Forgione of Manhattan's An American Place prepared a well-known Beard recipe for strawberry shortcake (see recipe). Bradley Ogden of San Francisco's Campton Place Hotel struck the eclectic note of today with blue corncake with caviar. Paul Prudhomme, the bearded and Beard-size New Orleans restaurateur, overwhelmed Rockefeller Center's ventilation system with the smoke from his Cajun blackened redfish. At other buffets, representing other restaurants, there was orthodox Spanish roast suckling pig and unorthodox grilled shrimp-and-scallop brochette with peanut chili butter (see recipe).

Had Beard been present for this ambulatory feast, he would surely have been struck by two things: the emphasis on regional or ethnic specialties and the readiness to combine ideas and ingredients that had never been mixed before. If cooking had ever had a "modern" period, it would be appropriate to call this new menu postmodern. Certainly it shares with postmodern architecture an unabashed zest for slapping together classic motifs and elements of the past in unexpected and ostentatious ways. None of this would have escaped Beard, who had so lovingly wallowed in classic American cookery and watched it coalesce into a cuisine.

That was the trend, at any rate, that Beard proclaimed more than a decade ago. He thought he saw a national cuisine evolving out of all the bits and pieces, the snickerdoodles and flautas and scrapples, that until then had resisted confederation into a coherent, European- or Asian-style cuisine. At the time, I thought he had succumbed to a delusionary bout of gastropatriotism. Now, however, given the evidence of the Rockefeller Plaza evening and certain recent experiences in other restaurants, and after reading some of the new cookbooks coming out of the West, I begin to think that Beard had sensed the wave of the future long before it actually swelled.

What is afoot in our land is not the birth of a vernacular cuisine in the traditional sense. That would be impossible. Wit exception of Native American recipe cluding Aztec dishes that may have eaten here before geopolitics conv them into Mexican food), nothing we sume has evolved in the autochtho slow manner that produced the cuisir traditional cultures. We lack, fur more, the standard focuses of cuisin mation; we have no court and no peas It was, in fact, in the American analo of royal and peasant kitchens that ou gional dishes did develop—in the br creative moments of princely wealth i lonial cities and southern plantations when pioneers adapted European cui to the natural world of the frontier. these short periods of culinary inve did not survive the homogenizing forc settlement. Regional dishes survive relics, endangered items on a menu tro out mostly for visitors.

A typical example of this kind of s case regionalism flourishes near the ver rail yards. The Buckhorn Excha bills itself as a "historic museum, res rant and saloon." The two-story Victo building is chock-full of game trop and frontier art. The menu features Ro Mountain oysters (sheep testicles: ob chewy, and insipid), buffalo, and elk.

In the real world outside, a monstro efficient agribusiness network, lin farming regions by truck with big-city permarket chains, has long since un mined true gastronomic regionalism most completely. As a creative prop tion, regionalism dried up when poly immigration swamped the eastern ci pristine colonial cultures and when m anization sent farm families packing find jobs in town.

But the regional foods did not c pletely perish, and knowledge about th persisted and spread, especially a 1980. By then, a generation of Americ

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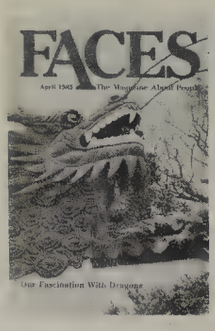


had lived through the so-called culinary revolution. They had been to Europe and had learned firsthand what traditional cuisines were and how to cook them. They had also observed how the most famous French and Italian restaurants prided themselves on keeping regional foods and food ideas alive on their tables. By 1980, a new freedom had also swept through previously conservative and culture-bound French restaurant kitchens. The *nouvelle cuisine* reveled in exotic ingredients and bizarre food combinations presented with a Japanese flair.

By 1980, French *nouvelle cuisine* restaurants had opened in this country on both coasts. But at the same time, Americans well grounded in French ideas combined the new European grammar with an American vocabulary. Especially in California this meant mixing ingredients with ahistorical abandon and putting special emphasis on ingredients of a markedly local and recherché sort—wild mushrooms, native chestnuts, fiddlehead ferns.

At Rockefeller Plaza, one of the practitioners of this new eclecticism, Jeremiah Tower, passed out menus from his San Francisco restaurant, Stars. Among the daily specials listed were lobster gazpacho, mint aioli, rillettes of smoked fish, and oysters with spicy lamb sausages.

You don't have to travel to California to sink your teeth into this *nouvelle* mash. You can try it yourself at h thanks to two new books. Should you to sample the deep-fried catfish in nese sauce made from sake, rice vi and soy sauce that Wolfgang Puck vides diners at Chinois on Main in S Monica, there is a recipe for it in I and Paul von Welanetz's *L.A. Cu The New Culinary Spirit* (Tarcher). same primer will open the way for y taste John Sedlar's Franco-Santa Fe ing, as exemplified by the green relleno, stuffed with mushrooms du and served with garlic chèvre sauce, he prepares at Saint Estephe in Ma tan Beach, California.

There is more of the same in I West Eckhardt's *The New West C Cuisine* (Tarcher), from saffron chall jalapeño hollandaise. Eckhardt expo a new cuisine she sees pullulating Vancouver to San Diego. Her re stress local products, the Pacific coast nic mix, and the health food "traditi

I am not convinced that her cranb salsa or any of the other concoctions i book will survive into the next cen But I do think that some of the dishe and her wild western colleagues are rently making up will turn into clas Even if they don't, it is the approach matters.

Two recipes slightly adapted from *A Celebration of James Beard* (a booklet distributed at the City Meals On Wheels dinner)

Jonathan Waxman's Grilled Shrimp-and-Scallop Brochette with Peanut Chili Butter

- 4 ounces shelled Key West shrimp
- 4 ounces fresh sea scallops
- 1 lime
- 2 tablespoons olive oil
- 1 serrano chili
- 1¼ cups shelled roasted peanuts
- ¼ cup sweet butter cut into small cubes
- Salt and pepper
- ¼ cup sweet butter cut into large cubes
- 2 tablespoons chopped parsley

1. Mix shrimp and scallops with juice of 1 lime and 1 tablespoon olive oil. Skewer shrimp and scallops on four brochettes, alternating shrimp and scallops. Marinate for one hour.
2. Deseed and stem the chili, then chop fine. Put peanuts into the jar of a food processor, followed by chili, small cubes of butter, and remaining tablespoon of olive oil. Pulse machine to purée. Season to taste with salt and pepper. Transfer to a medium saucepan.
3. Make a sauce by adding ½ cup ice-cold water to purée from processor. Place over medium heat. Add large cub butter and beat with a wooden s until homogenized. Adjust season
4. Grill brochettes over medium-flame on a charcoal grill 2 to 3 utes, turning once. Transfer to ser plate. Spoon sauce beside broch and sprinkle with parsley.

Yield: 4 brochettes

James Beard's Shortcake

Biscuits

- 4 cups all-purpose flour
- ¼ cup plus 2 tablespoons sugar
- 3¼ teaspoons cream of tartar
- 1¾ teaspoons baking soda
- 2 teaspoons salt
- 6 ounces unsalted butter, chilled cut in small bits
- 1½ cups heavy cream
- 4 hard-cooked egg yolks, mashed
- 4 tablespoons unsalted butter, mel

Berry Filling

- 3 pints berries, such as raspber blackberries, or strawberries
- 2 tablespoons sugar
- 1 pint English double cream or 1 heavy cream, whipped

1. Heat oven to 375 degrees.
2. For the biscuits, sift flour, su cream of tartar, baking soda, and

ie von Welanetzes are definitely on to ething when they talk about the new iary spirit. The Californian willing- to experiment is not just an unbridled enture. Most of the people getting into very interesting act are building on l knowledge of several vernacular tra- ons and mixing them up with a good se of what will work and what won't. To te the classic French emulsified sauces n chili is not barbaric; it follows logi- y from age-old Provençal practice— y aioli, a garlic mayonnaise, points to- d "hot" hollandaise. With the fiercer erican newcomer, something is lost, naps, but something is gained.

The main interest of postmodern Amer- n cuisine, at this early stage, is its free informed attitude toward the rich ld of possibilities open to American ks. Perhaps a vocabulary of new nerican" dishes will ultimately shake of all the fervid experimentation. But how it is the process that counts. The nipulation of local ingredients with cu- ry ideas inherited from many national ts is a sensible extension of the notion he melting pot—and an intrinsically erican way to go.

ymond Sokolov is a writer with a spe- l interest in the history and prepara- of food.

nto a bowl. Cut in butter bits with a pastry cutter or by working quickly with fingertips. The pieces of butter should be blended until quite small. Add cream and mashed yolks and stir quickly until dough clings together.

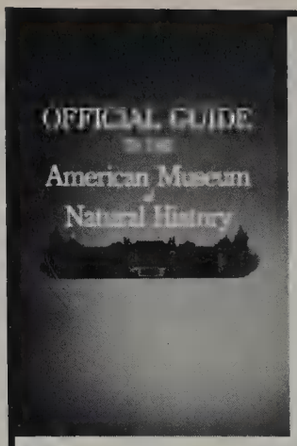
Turn out on a floured board, knead a few times, and pat or roll out to ½- to ¾-inch thickness. With a 3-inch, floured cookie cutter, cut 6 rounds, and with a 2½-inch cutter, cut another 6 rounds. If needed, use scraps to re-roll. Arrange larger rounds on lightly buttered cookie sheet. Brush each with a teaspoon of melted butter. Top with 2½-inch rounds and brush tops with butter.

n a small bowl, mix berries and sugar, oss, and let sit while the shortcake is baking.

Put cookie sheet with biscuits in a pre-heated oven on middle shelf. Bake until firm to the touch and golden brown, 12 to 16 minutes.

Transfer the biscuits to serving plates and remove the top (smaller) layers very carefully. Spoon the berries over the bottom layers and put a dollop of cream on each one. Place the smaller layers on top of the cream and serve immediately. Serve the rest of the cream on the side.

Yield: 6 servings



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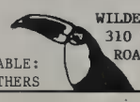

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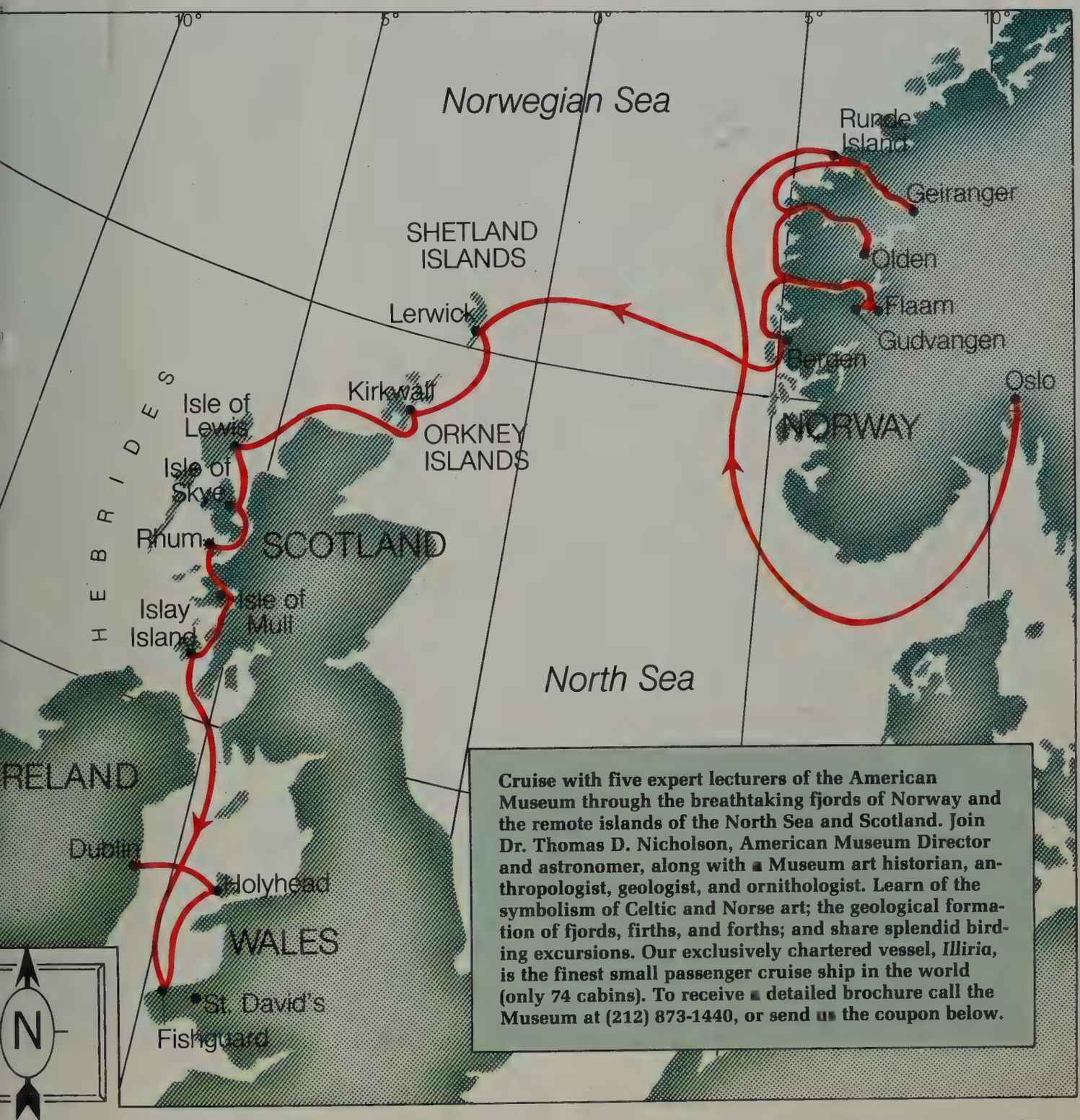

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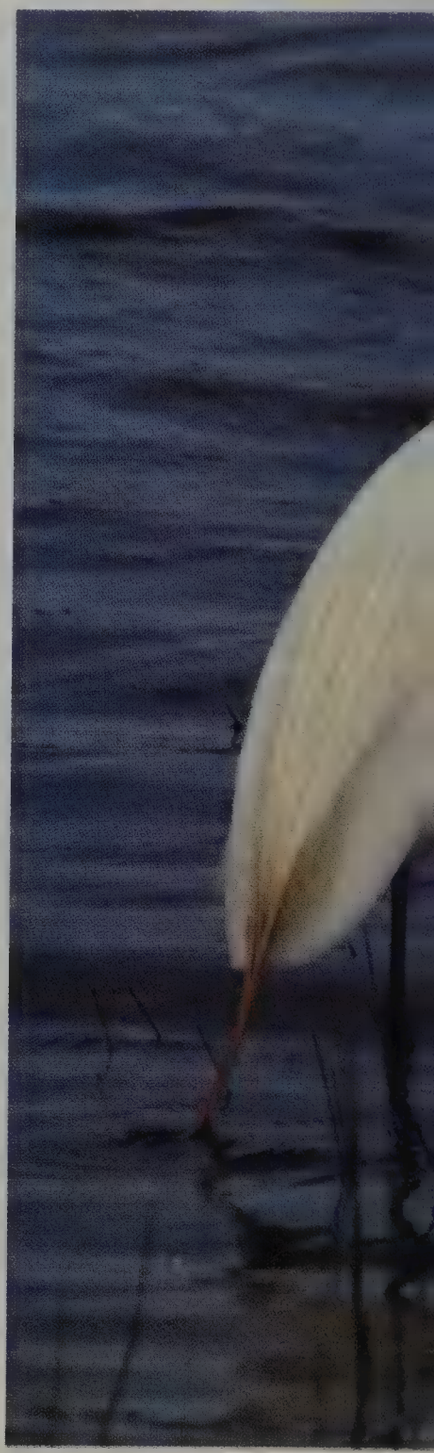

Early one May morning, while dri
slowly through Chincoteague Nati
Wildlife Refuge on the eastern shor
Chesapeake Bay, photographer To
send Dickinson spotted a great egret
aging near a dike at the edge of a fresh
ter impoundment. Dickinson stop
turned off the engine, got out of the
and using the car as a blind, rested
camera on a shoulder holster and focu
on the bird.

Suddenly, the egret plunged its bill
the marsh vegetation at the edge of
water. Then, stepping back, it brough
a medium-sized rodent (whether it w
meadow vole or a Norway rat was ne
determined because the animal soon
came inaccessible for positive identif
tion). The animal struggled briefly, but
tilely, and soon went limp.

The bird then maneuvered the roden
as to swallow it headfirst, but appare
decided it was not quite ready to eat. S
holding the dead animal in its bill,
great egret dipped it in the water, gave
powerful squeeze, and repositioned it
swallowing. The dipping, crushing,
positioning sequence was repeated seve
times over until the egret finally sw
lowed the rodent.

The whole procedure took less than f
minutes. To take this series, Dickin
used a 400-mm lens on his hand-held ca
era and shot the photographs at a h
shutter speed to minimize any possi
camera movement.

The great egret (*Casmerodius alb*
usually feeds on crustaceans, fishes, fro
snakes, and an occasional small mamm
In this case it had to handle a larger-th
usual mouthful, but it lived up to its re
tation as an opportunistic and omnivor
predator.

Additional Reading

Burma Fossils (p. 26)

Russell L. Ciochon's "The Search for Fossil Man in Asia" (*The Explorer,* Winter 1976, pp. 7–17) is a lively account of the quest for early man in Burma and other parts of Asia and the explorers who carried it out. *Primate Evolution and Human Origins,* by Ciochon and John G. Fleagle (Menlo Park, CA: Benjamin Cummings Publishing Co., 1985), includes a pertinent review of prosimian and early anthropoid evolution, as well as sections on the origin and evolution of the human lineage. Ciochon and A.B. Chiarelli edited *Evolutionary Biology of the New World Monkeys and Continental Drift* (New York: Plenum Press, 1980), which looks at these monkeys from a wide perspective, ranging from anatomy and paleontology to biogeography and continental drift theory. Several chapters discuss *Amphipithecus* and *Pondaungia.* Edwin Colbert, the noted American Museum paleontologist who published the original description of *Amphipithecus,* "A New Primate from the Upper Eocene Pondaung Formation of Burma" (*American Museum Novitates,* No. 951, 1937), was also the first, in this article, to make a strong case for the origin of the anthropoids in Asia. Barnum Brown, who collected fossils for the American Museum during the first half of the twentieth century, wrote a popular account of his expedition to Burma for *Natural History* (May–June 1925, pp. 294–308). Also interesting is Colbert's *The Great Dinosaur Hunters and Their Discoveries* (New York: Dover Publications, 1984), which recounts some of Brown's most famous discoveries and accomplishments.

Wild Radishes (p. 46)

A.C. Martin's *Weeds* (New York: Golden Press, 1972) is one of the best guidebooks available. It provides a good introduction to the subject, is suitable for children as well as adults, and is reasonably inexpensive. Like *Weeds,* C.B. Clarke's *Edible and Useful Plants of California* (Berkeley: University of fornia Press, 1977) is available in p back; it is chock-full of information wild radish and other weeds and ev cludes recipes. C.A. Panetsos and Baker uncover the unusual species variation in wild radish in "The Ori Variation in 'Wild' *Raphanus sativ* California" (*Genotica,* vol. 38, pp. 74). "Gene Flow in Seed Plants," by Levin and H.W. Kerster (*Evoluti Biology,* vol. 7, pp. 139–220), is the c review of dispersal of pollen and seed tailing and evaluating hundreds of e mental and descriptive studies.

Humpback Whales (p. 52)

Lois King Winn and Howard E. W *Wings in the Sea* (Hanover, NH: U sity Press of New England, 1985) is a ough, reliable, and up-to-date accou the humpback whales. *Cetacean B ior,* edited by Louis M. Herman York: Wiley-Interscience, 1980), inc a number of chapters about humpb

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ling coverage on the whales' com-cation systems and songs as well as pertinent topics. Roger Payne edited *nunication and Behavior of Whales* der: Westview Press, Inc., 1983), a of articles based on lectures pre-l at a AAAS symposium that deal humpback songs, vocalizations, be-r on the breeding grounds, and pat-of migration. The humpbacks' social ization at their wintering grounds in ii and the Caribbean is treated in Pe-yack and Hal Whitehead's "Male petition in Large Groups of Winter-umpback Whales" (*Behaviour,* vol. p. 132–54). The whales' broadside ys, head lunges, charge-strikes, and characteristic aggressive behaviors e grounds are discussed by C. Scott r and Louis M. Herman in their tech-article "Aggressive Behavior Be-n Humpback Whales (*Megaptera eangliae*) Wintering in Hawaiian rs" (*Canadian Journal of Zoology,* 2, pp. 1922–37).

Desert Palm Oases (p. 64)

When it is released sometime late in November, James W. Cornett's *Ecology of the Desert Palm Oasis,* published by the Palm Springs Museum, 101 Museum Drive, Palm Springs, CA 92263, will constitute the most exhaustive treatment of palm oases to date. The book's nine chapters will cover the hydrology of the oases, the growth and development of fan palms as well as their ecology, and the birds and other animals that live there. Palm aficionados may wish to contact the Palm Society (P.O. Box 368, Lawrence, Kansas 66044), which publishes a quarterly journal, *Principes,* especially for them. Articles range from technical papers to anecdotal reports of personal experiences with palms, and fan palms are often covered. The late Randall Henderson, who carefully counted individual trees and kept records on the palm oases of the Colorado Desert, wrote a series of articles about them for *Desert* magazine, which he edited and published. The articles, forty or so in total, appeared from 1938 to 1965.

Chilean Mummies (p. 74)

Since most of the Chilean mummies have been rediscovered in bulk only recently, not much has been written about them yet. An excellent source of information, however, is available to those who can read Spanish: *Chungara Arica,* a journal put out by the Instituto de Antropología at the Universidad de Tarapacá, Chile. The November 1984 issue (volume 13) contains a number of articles about the Chinchorro. The late noted archeologist Junius B. Bird discussed the Chinchorro and described his unearthing of a grave site in "Excavation in Northern Chile" (*Anthropological Papers of the American Museum of Natural History,* vol. 38, part 4, 1943). Marvin J. Allison's "Paleopathology in Peru" (*Natural History,* February 1979, pp. 74–82) reports on his studies of ancient Indian mummies, which revealed that some industrial diseases are more than 2,000 years old.

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Authors

In 1975, **Russell L. Ciochon** (page 26) laid plans for an expedition in search of the origins of the higher primates. His quest took him to a remote part of Burma, explored earlier in this century by Barnum Brown, the American Museum's legendary fossil collector. Ciochon is pictured (far right) with (left to right) his American co-worker, paleontologist Donald E. Savage, and Burmese geologists Tin Maung Oo, U Ba Maw, a Thaw Tint. Related fieldwork has t Ciochon to China, India, and Indon He did his graduate work at the Un sity of California at Berkeley and taught at the University of North C lina at Charlotte. He is currently search associate in the Departme Anatomical Sciences at the State versity of New York, Stony Brook.

Norman Ellstrand (page 46) suspected that California wild radishes were up to something more than simple mating. His interest in the sexual practices of this unusually varied weed species was sparked during a general study of the breeding systems of other plants. Convinced that basic questions could be answered only by identification of parent plants, Ellstrand brought the precision of genetics to bear on his fieldwork. His research confirms that multiple paternity occurs in plants and also delineates its possible mechanisms. An assistant professor of plant ecology at the University of California at Riverside, Ellstrand has launched a plan for commercial production of the New World fruit cherimoya on the West Coast. When not in the field or the lab, Ellstrand devours fiction—fantasies, mysteries, and science fiction. A cherished ambition is to write a successful novel himself.

ust because somebody has a Ph.D. sn't mean he knows exactly what he ts to study. After five years of pursu- humpback whales to the ends of the th Pacific, **C. Scott Baker** (page 52) s he is "just beginning to see what stions are interesting." Baker, whose toral work at the University of Ha- i has focused on seasonal contrasts in great black whale's behavior, wants consider what individual whales are ng. "We have an unfortunate and que situation in the North Pacific, in t hunting has reduced the population umpbacks to only about 1,200 ani- s," he says. "This means we can indi- ually identify a large percentage of whole population. You could never that with dolphins, for example." owing individual whales means that mpback researchers can look at the ales' sex life and migration patterns in ch greater depth. Coauthor **Louis M. rman** is the director of the Kewalo Ba- Marine Mammal Laboratory at the iversity of Hawaii, where he has stud- humpback whales and dolphins since 70 and sponsored students like Scott ker. He is also a professor in the uni- sity's psychology department, and he ches animal behavior, especially ma- e mammal behavior. Herman re- ved his Ph.D. from Penn State Uni- sity. His book, *Cetacean Behavior,* s published in 1980 by Wiley erscience.

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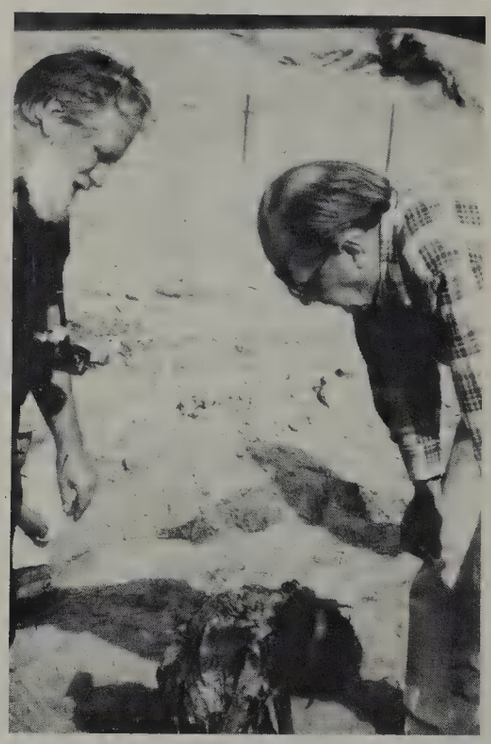
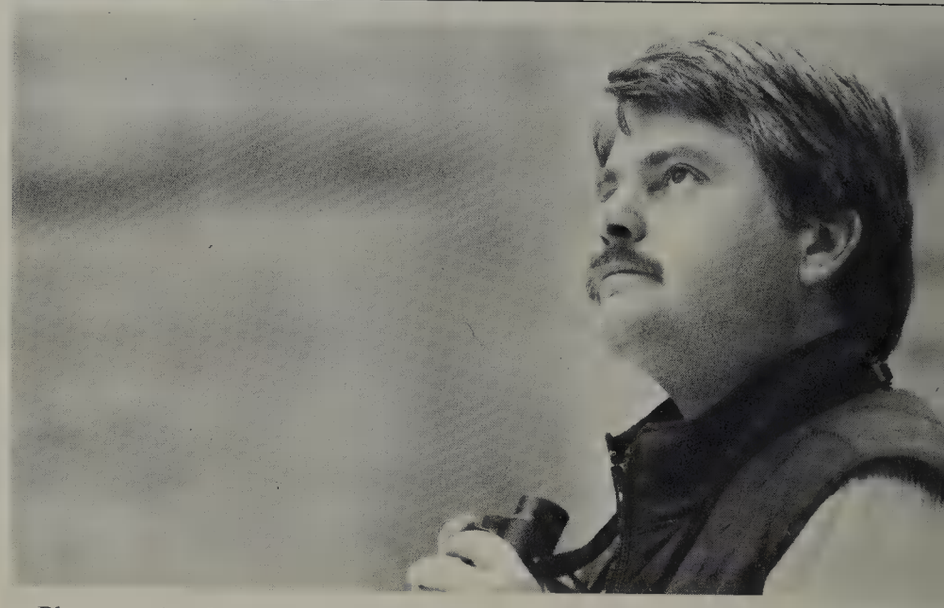
Plant and animal ecologist **James W. Cornett** (page 64) says, "I have been enthralled by the beauty of desert palm oases since I was a teen-ager, but it wasn't until I was a graduate student that I began to examine the oases seriously." That interest explains how he came to write about palm oases in this issue. Cornett became curator of natural science at the Palm Springs Desert Museum in 1980 after working there for five years. Field trips to study the ecology of desert organisms have taken him to the southwestern United States, the Atacama Desert of Chile and Peru, the Australian Desert, and the Vizcaíno Desert of Baja California. Investigations of two more deserts—the Gobi and Sahara—are part of his future plans.



In 1969, while on an assignmen the Standard Oil Company in **Marvin J. Allison** (page 74) becam trigued by the medical histories o natural (sun dried) mummies. In he started studying the artificial m mies of northern Chile as an avoca while he taught clinical pathology a Medical College of Virginia in mond. Although he is still affiliated the medical college, Allison is now a time faculty member at the Unive of Tarapacá in Chile and has an offi amid hundreds of mummies—at the versity's Museum of Archeology o outskirts of Arica. Allison and his leagues adapt many modern techni of forensic pathology to study the cient mummies. He is shown here (a right) with *Natural History*'s ed Alan Ternes, at one of the grave sit northern Chile.



Photographer **Townsend P. Dickinson** (page 116) bought his first New York Lotto ticket for the $41 million prize in August. "If I'd won," he says, "I would have spent the rest of my life out in the field photographing birds." As it is, he spends much of his time indoors working as the senior photo editor at a commercial photographic stock house in New York City. But birds are his first love. He doesn't photograph them simply looking pretty, as though posed for an ID card or a nature yearbook. Instead, he tries to catch them doing something teresting. To find out what that m be, he reads a great deal of the scien literature on bird behavior. Then in free time, and financing most of his t himself, he journeys forth armed w binoculars, camera, lenses, and patie A project Dickinson would like to ca out is to visit all the sea bird colo ringing the North Atlantic. His ph graphs in this issue were taken wit high-speed, motor-driven Canon F-1 a 400-mm lens.

The American West in All Its Glory

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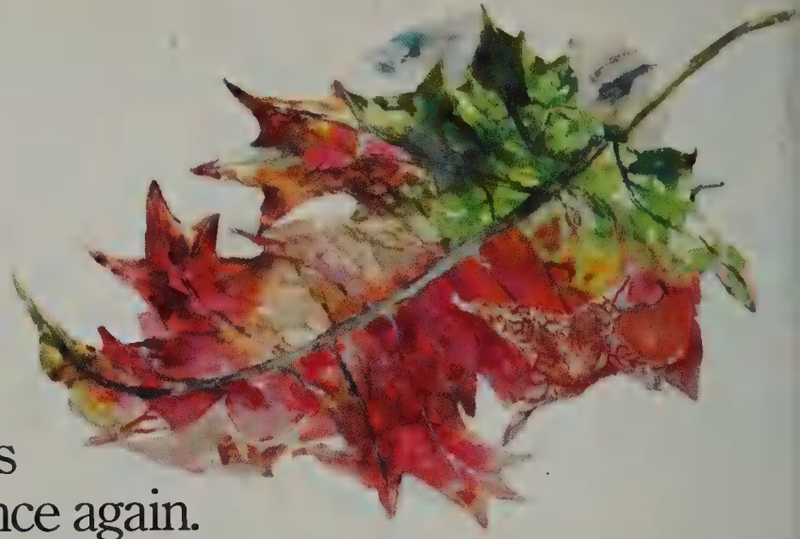

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Vol. 94, No. 11, November 1985

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Cover: *Herbert Dunton's* The Shower, *circa 1914, is part of a national exhibition of western art that opens November 29 at the American Museum of Natural History. Story on page 58; exhibition details on page 90.*

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Thanksgiving in the Monte

In the dense forest of Paraguay, an anthropologist and a family of hunter-gatherers share a feast

by Kevin T. Jones

I took one last glance back at the truck and was filled with the same mingled anticipation and dread I had experienced as a child when my mother left me at the bus station for a trip to visit relatives. But this time Hillard Kaplan, my anthropologist colleague from the University of Utah, had dropped me off, and I was heading into the jungle on a hunting and gathering expedition with a band of Aché Indians. Kaplan had driven me, Kim Hill, the leader of our research group, and twenty-four Aché as far down the road past the newly cut fields as the pickup could go. From there we set out on foot into the heart of the Aché's traditional territory, the thick forest, or *monte,* of eastern Paraguay. It was Thanksgiving Day, 1984.

We had walked for only about fifteen minutes when Kuaregi, the oldest of three brothers whose families made up the core of the group, took an ax and began chopping into the rotting wood of a fallen pindo palm tree. Several people gathered excitedly nearby, and I soon found out why: Kuaregi was chopping out the big, fat, white palm beetle larvae known as *buchu.* Someone handed me one, and I held it awkwardly, amazed at the strength of the 1½-inch-long grub and aware of its nasty-looking jaws. Kim showed me how to pinch off the head and said, "Just pop it into your mouth. It tastes like creamed corn." The Aché were eating the grubs with gusto, and rather than think about it, I put the larva in my mouth and chewed away. It did taste like creamed corn, but the skin was unexpectedly tough, something like I imagine raw chicken skin might be. "Welcome to the *monte,*" Kim said. "Happy Thanksgiving."

We were in Paraguay to study the ecology, demography, child care, and archeology of the Aché, research sponsored by the National Institutes of Health. Hill had lived and worked with the Aché for more than three years since 1978; Kaplan had spent nine months with them in 1981 and 1982. This was my first visit.

Until recently, the Aché, traditional hunter-gatherers, roamed the neotropical forests between the Paraná and Paraguay rivers, subsisting on wild game, fruits, vegetables, and honey. Their technology was simple but perfected to exploit the region's resources. The men carried powerful palmwood bows and long, barbed arrows. The women managed large burden baskets, or *nokos*, plaited from pindo palm leaves, as well as stone-bladed axes, beeswax-covered baskets for transporting water, woven mats and fans, and of course, children. The Aché love pets and often keep young capuchin monkeys, coatis, birds, or peccaries and carry them on their heads or in baskets.

The forests of eastern Paraguay are dense and hard to traverse. This physical barrier and, until recently, the rather small Paraguayan population, kept the Aché in relative isolation until the mid-twentieth century. Many Aché did not make friendly contact with Paraguayans until the 1970s, and some, including most of the members of our foraging band, came into peaceful contact only in 1978.

The group we work with, known as the Northern Aché, number approximately 300 and now live on a parcel of land called Chupa Pou, or New Camp, provided by the Catholic Church. They are learning how to farm and raise domestic animals, but many still spend a considerable amount of time foraging in the surrounding forests, living in the old way. Although they now possess metal axes, machetes, and knives, the Aché still obtain food in the *monte* by traditional methods, using their hands, bows and arrows, and axes for most hunting and gathering tasks.

While I was still chewing my first *buchu*, Kuaregi declared that there were no more larvae in that tree, and everyone quickly resumed walking. Kuaregi led the way, carrying his bow and arrows in one hand, a machete in the other. He cut an occasional branch or vine, but otherwise wound his way expertly through the undergrowth. After a few minutes Kim and the other five men slipped quietly into t forest to hunt. The women, children, an followed Kuaregi.

We wove our way, single file, throu the forest, squeezing through small ope ings in the vegetation, ducking und vines, climbing over fallen trees. W waded through the waist-deep water of wide, swampy bog and scrambled up t steep, muddy bank on the other side. Tw girls, each about twelve years old, ran to nearby tree and climbed quickly to t spreading branches some forty feet abo the ground. They shook the tree back a forth until a volley of bright orange, w nut-sized fruits peppered the grou around us. A woman handed me a plum juicy fruit and said, "This is *virella.* It very sweet." I tasted it, and though swe the fruit also stung my mouth a little, as it contained a small amount of acid toxin in the fruit or seeds. November is t height of the season for *virella* and also f *pretylla*, a grape-sized red fruit. We a hundreds of these fruits in the next fe days, usually consuming nearly all of the on the spot. A few were gathered and ca ried to the evening's camp.

At times during the day we heard hig pitched calls from the men who were hu ing. Kuaregi or the women would answ and then tell me what had been commu cated: "They have found a peccary trai or, "They are chasing monkeys." I was a tounded by their ability to understand t calls, which seemed to come from a gre distance. Kim estimates that the Aché c call and exchange information over d tances of up to three-fifths of a mile, impressive feat in forests so profusely ve etated that light scarcely penetrates the

As we walked behind Kuaregi—up a down hills, through thick, thorny patch of bamboo, across small milky-color streams—I thought that we had be walking in circles. Convinced of this, I b gan to doubt the accuracy of my compas which indicated that we had hardly de ated from a straight south-southwe course. I realized that although I ha

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spent a lot of time hiking and camping in the United States, my sense of direction failed me in the jungle. The vegetation blocks anything more than about thirty feet away and even makes locating the sun difficult.

On the side of a gently sloping hill we stopped walking and the women took off their *nokos* and sat down. One of them kindled a fire, and then others took burning branches from the blaze and started their own fires. The women often light fires during their frequent rest stops, especially when mosquitoes or other insects are bothersome, because the smoke deters the bugs. These days the Aché have access to matches and lighters, but these niceties are rarely used on foraging trips. The Aché prefer to carry a piece of smoldering wood, which can be used to start a fire much more quickly than can matches or a lighter.

We had been resting for a few minutes when Kuaregi picked up an ax and headed up the hill. "He is going to chop some honey," one of the women told me. At the same time two of the women hefted axes and walked in the opposite direction. "They are going to chop palms," I was told. I got up and followed Kuaregi. He walked a short distance back along the way we had come, then went about thirty feet off the path to the foot of a large hardwood tree, about two feet in diameter. He pointed to a spot some twenty-five feet above us, and I could see a hole through which bees were coming and going. Apparently I had been the only one not to notice the tree when we passed by it earlier. While I was wondering how he was going to reach the hive, Kuaregi began chopping at the base of the tree.

I knew it would take a while to fell the tree, and hearing the sound of axes hard at work from near our resting spot, I left the honey tree to see what the women were doing. I walked toward the sound and found myself thrashing through the brush, getting entangled in vines, crawling through the branches of a fallen tree. I must have sounded like a truck crashing through a fence because when I finally reached an opening, Kuaregi's wife, Kry'ygi, and several children were looking at me and laughing. "It is Kry'ygi [also my Aché name]; he doesn't know how to walk in the forest yet," one young girl giggled. I joined in the laughter. Walking in the jungle is a skill that comes with practice, and even children of five or six years held a great advantage over me.

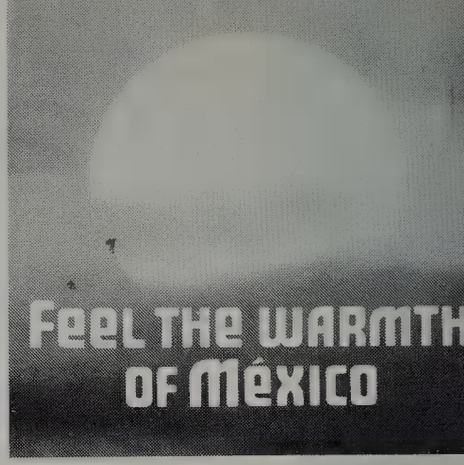
As I brushed myself off, Kry'ygi picked up her ax and resumed chopping. I was taken by the ease with which she handled the ax. The strokes were perfectly placed and came in a smooth, powerful cadence, each blow cleanly slicing free a large chip of the palm wood.

In five minutes Kry'ygi was nearly through the twelve-inch palm. She told the children and me to move out of the way and then, with about six more blows, brought the tree down. She next moved to the crown, pushed back the outer fronds, and chopped at the center. In a few minutes she pulled out an eighteen-inch-long, four-inch-wide white cylinder, the palm heart. She ripped off and discarded a few strips of the stringy material that sheathed it and tossed the heart on the ground near her daughter, who broke off several pieces and offered me one: "This is *tangy*." Cool, moist, and delicious, *tangy* immediately became one of my favorite jungle foods.

Kry'ygi came over to her children and stopped for a minute to play with the baby, who hadn't been pleased to have been left in the care of his sister. She then went back to the tree and chopped a small square "window" through the bark. Flipping the ax over, she pounded the fibrous wood with the blunt end of the axhead. After about a dozen blows she pulled out and sampled a handful of the stringy orange pulp. "It is sweet," she said. Apparently satisfied with the quality of the fiber, which the Aché call *kraku*, she opened a three-foot-long section of the trunk. All in all, Kry'ygi extracted about thirty pounds of *kraku* that day. Most of it was eaten by the women and children at the rest stop by simply placing a large handful in the mouth and sucking on it until the sweetness was gone. Another common way of eating *kraku* is to squeeze the fiber in water and to use the bróth for boiling meat.

I was noisily enjoying my fifth mouthful of *kraku* (eating it is something like sucking on a wet, sweet, frayed hemp rope), when I heard branches cracking, quickly followed by a very loud crash. I had nearly forgotten about Kuaregi and the honey tree. Kuaregi called for someone to bring fire. As one of the women picked up a couple of burning sticks, the children scrambled for all the available pots and containers, and then we hurried toward the tree.

Kuaregi was leaning against the trunk of the fallen tree, taking a short breather after felling the huge hardwood. A few beads of sweat dampened his forehead and upper lip. I noticed this primarily because the Aché perspire very little, whereas I was constantly dripping in the hot, humid climate. The woman who had brought the burning sticks thrust them into a pile of dry leaves and wood that Kuaregi had gathered and blew on them until the mass burst into flames. Kuaregi took a smoldering piece of wood in one



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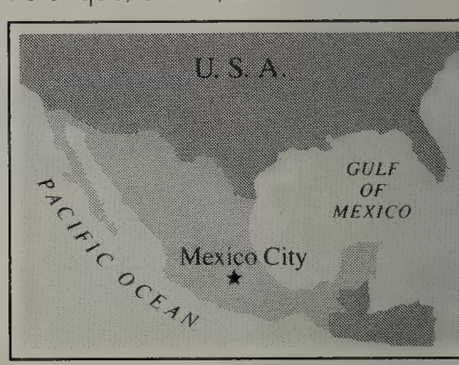

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hand, his ax in the other, and headed for the hive, now only a few feet above the ground and surrounded by a thick, noisy swarm of bees. He rather nonchalantly held the stick near the opening for a few seconds, then laid it on the tree and began chopping. In a manner very similar to the way Kry'ygi had opened the palm tree, he cut a square "window" around the hive opening. He appeared undaunted by the bees, although there were dozens of them on his bare chest, head, and back.

He took more burning sticks and held them over the window, blowing occasionally to direct the smoke into the hole. Bees were now all over him, covering his head and torso like a hooded shirt. He then reached into the tree, pulled out huge chunks of comb, and dropped them on a pallet of leaves that the women had placed on the ground at his feet. He was stung a few times on the hand and arms but not nearly as often as I would have expected.

The women and children gathered the pieces of comb as Kuaregi dropped them and put them in buckets and pans. Some of the pieces were dripping with honey, while others were dry, being either empty or containing only undeveloped bee larvae. Everyone was eating both honey and larvae. Extra honey was put in containers for later use, but the larvae were all consumed on the spot. The honey was eaten by putting a piece of the comb in the mouth, chewing and sucking until only wax was left, and then spitting it out. The larvae were slightly sour-tasting and quite good, while the honey rivaled the best I have ever tasted.

The six quarts of honey not eaten at the tree would be carried to the evening's camp, mixed with water, and drunk. The Aché warned me not to eat too much "straight" honey or I would get a stomach ache. When it was mixed with water, they said, I could drink as much honey as I could hold with no problem.

Honey was in season, and we ate it every day, although it varied in taste. Two kinds came from small, stingless "sweat" bees and were quite sour. Some was from a type of bee so aggressive that when the tree was being opened and the honey taken, the men made the women, children, and me stay at least one hundred feet away.

When all of the honey had been taken from the hive and the pieces of comb stashed away in containers, Kuaregi joined the children in licking and sucking the last of the honey from the leaves it had rested on. Then Kuaregi showed me how to clean up. He found a dry, rotting log, then broke off a chunk, crushed it in his hands, and vigorously rubbed the powdery wood dust on his sticky arms, chest, ar face. I tried it and was delighted to fi that the honey was completely absorb and removed, even from between my fi gers, which had been nearly fused t gether with the sticky substance.

We carried the honey-filled pots ar pans back to our resting spot, where t women packed them away in their *nok* While they were getting ready, Kuare headed off, and we once again began mo ing through the forest, following in sing file. We walked for a couple of hou mostly through thick stands of bamb with needlelike thorns and razor-sha leaves. Just as the light was beginning fade, Kuaregi stopped and began cutti the undergrowth down to ground lev with his machete. This was to be o camp.

He cleared an area about fifteen feet diameter, then each woman went to a d ferent spot along the perimeter of the s and took off her *noko*. The women th headed into the forest to gather firewoo Each collected wood for her own fi around which she and her family wou prepare food, eat, and sleep. They look for dead, dry, partly rotten logs from inches to one foot in diameter and fro three to eight feet long. The fires, one each family, consisted of five to twe pieces of wood extending out from t camp and burning at their converged nermost tips. Following the women's lea I made a fire and cleared sleeping pla for Kim and me.

When we completed camp, the wom sent three older children to get water fr the trickle of a stream that ran in a shall gully about fifty feet from camp. Wh they were gone, Jamo, the grandfath who had been out with the rest of the hu ers, returned. He walked silently i camp, sat down, and picked up a *da peka*, one of the small plaited fans t Aché make for fanning fires and swatti insects. He sat quietly, occasionally sla ping his back with the *dave peka*, and st ing off into the forest. After a few minu two of his grandchildren went to him a began searching his body for ticks, specting his back, neck, and armpits. remained silent and no one spoke to hi After about ten minutes he said, "Ther no meat." Everyone was disappointed. I spite having had palm beetle larvae, pa heart and fiber, two kinds of fruit, and l larvae and honey, I was hungry, and parently so was everyone else. Minu later we heard Kim and two of the m just outside camp. The Aché m stopped, leaned their bows and arro against a tree, and each dropped a sm bundle from his shoulders. Two boys

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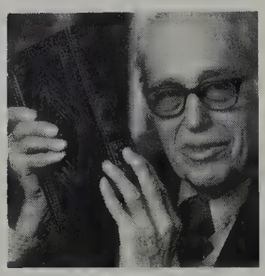

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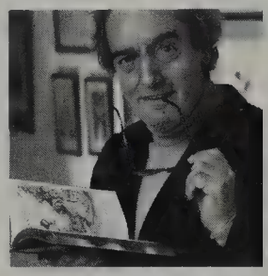

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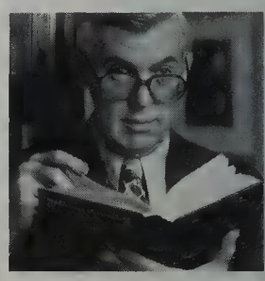

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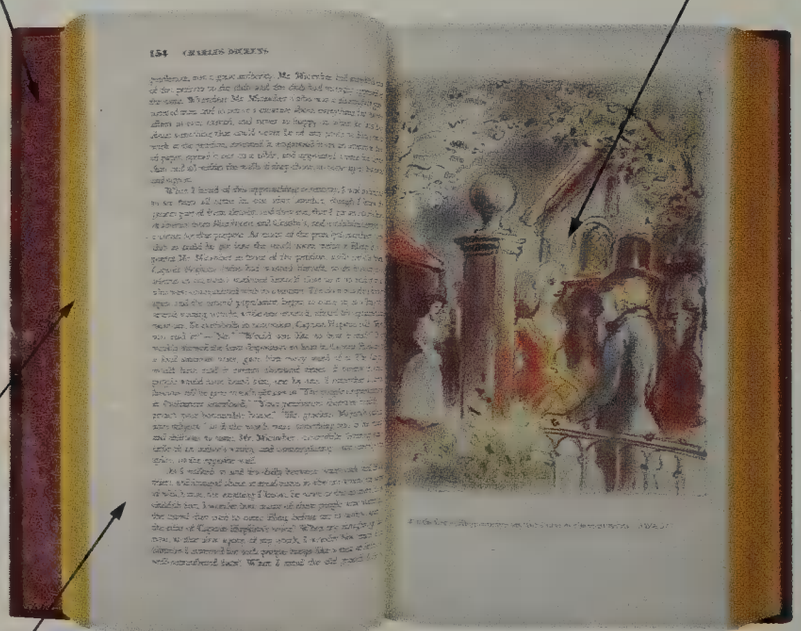

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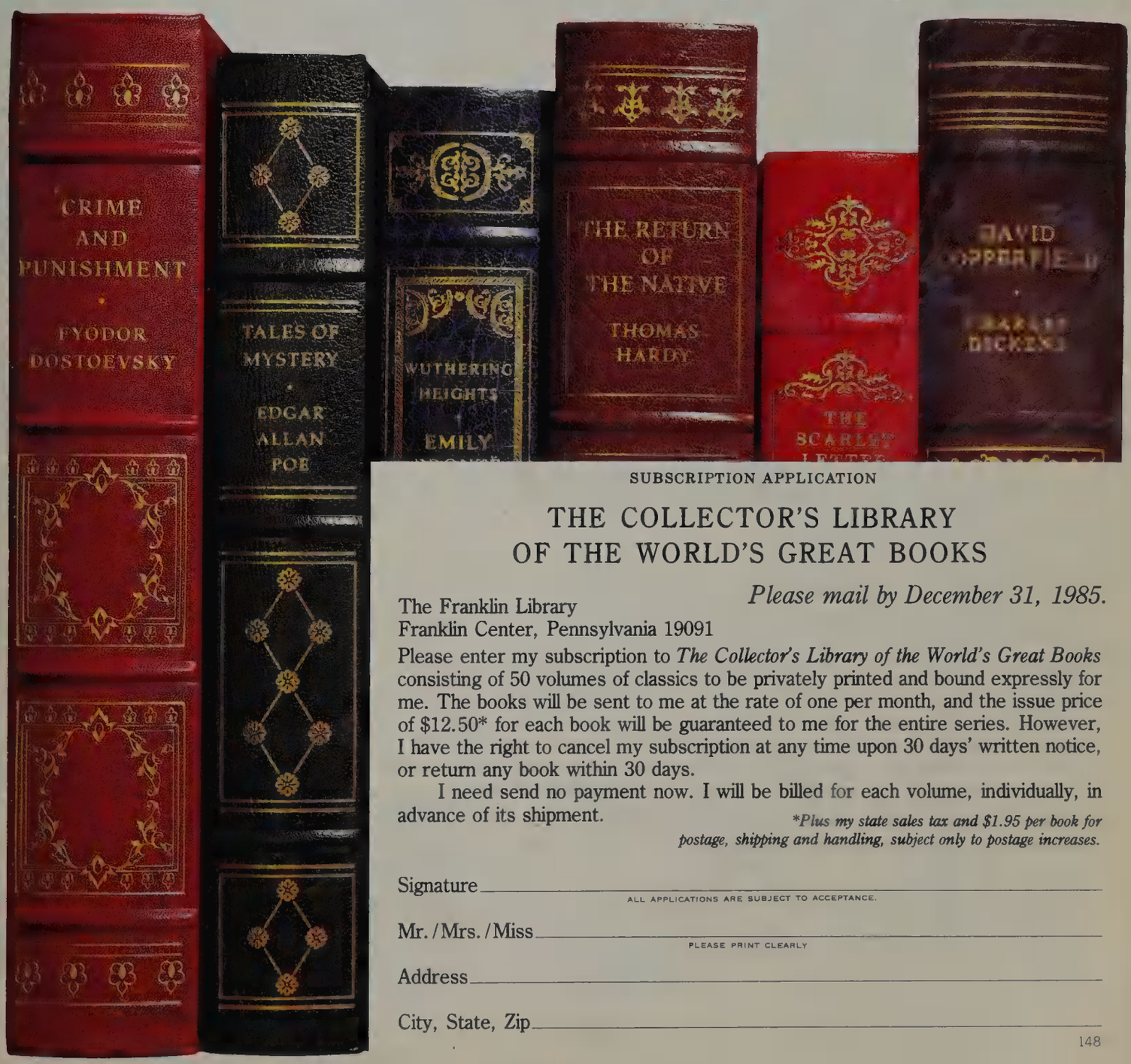

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Aché women and children begin a trek into the forest. The women carry large burden bags called nokos.

ting by me exchanged excited grins but remained silent.

The men ambled into camp and quietly sat down, as had Jamo. One of them motioned to his son, a boy sitting by me, to go over to the bundles. The boy jumped up and he and a friend ran to the spot. They returned beaming, one carrying a large adult female armadillo and one of her young; the other, two capuchin monkeys. We would not go hungry tonight after all.

Kim came over to our fire and sat down. He looked horrible. He had been stung four or five times by wasps and one eye was swollen shut. Small wasp nests in the vegetation were very active at this time of the year, and we all got stung several times a day. Kim's encounter was by far the worst of the entire band so far and reflected the higher risk of injury hunters take by running through the thick forest. The women and I picked our way through the brush and looked out for each other, but the men could not afford such luxuries, and were much more vulnerable to stings, snakebites, and even jaguar attacks. Luckily, the stings were not from the wasp the Aché call *cue'e pura*, whose sting allegedly causes nausea, difficulty in breathing, and sometimes a lapse into deep sleep—classic symptoms of allergic shock.

The Aché immediately began preparing the meal. The hair was singed off the monkeys, which were then cut up and placed in pots to boil. The armadillos were gutted, and the tail and internal organs were placed in the fire, then eaten as appetizers. Either men or women may cook meat, although a hunter will rarely cook and distribute game that he has killed.

While the meat was cooking the two remaining hunters strode into camp, carrying a baby jaguar they had killed. While tracking peccaries, they had apparently come upon a female jaguar and her cub feeding on a freshly killed peccary. The adult jaguar fled, but the cub ran up a tree and was killed by the hunters. The men also brought what was left of the peccary back to camp with them. There would be plenty of meat tonight.

The baby jaguar was a beautiful animal, and I felt more than a twinge of uneasiness when I saw it being carried into camp, and even more when I actually ate the animal (it was light, tender, juicy, and very tasty). Jaguars are, of course, an endangered species. The Aché, however, have no remorse about killing them and take every opportunity to do so. They look upon jaguars as fierce predators. Kim was with a group of Aché several years ago when a jaguar was heard circling camp in the middle of the night. Women and children huddled crying in the middle of the camp while the men took bows and arrow and stood ready to fend off an attack which fortunately never came. Lone Ach hunters are sometimes attacked by jag uars, and many have been killed by th cats. The father of one of the men in ou party was killed when he was dragge from the camp by a jaguar in the middl of the night as the others looked on. Still, wished that they hadn't killed the cub.

I wished it even more strongly whe Jamo, the grandfather (all old men ar called Jamo, which means, roughl "grandfather" but also means "jaguar" berated the hunters for killing the jagua and bringing it back to camp. "Th mother will be angry and will go lookin for her baby," he said. "She will smell here and come into our camp."

Once, in the middle of the night, w heard some noises in the forest, and th men sat up and listened intently before l ing back down to sleep. I was scared, but felt secure knowing that the Aché wer keeping watch. I was also very tired fro the long day and slept soundly. There wer no further noises, but in the morning, th men found fresh jaguar tracks nearby.

We spent another six days in the fore before walking back to Chupa Pou, ou notebooks full of information on the food collected by the Aché and the time spe searching for and processing them. W also collected data on child care, th butchering of game, and the discard bones and other refuse.

We are particularly interested in th Aché because they still practice huntin and gathering, as did all of our ancesto for most of the evolutionary past of our g nus. We have focused on their ecology an attempt to learn about the ways peop with simple technology cope with the environments. And although our emph sis is on quantitative data collection, th has not kept us from establishing clos friendships.

One of the bonuses of anthropologic fieldwork is the opportunity to meet an live with people like the Aché. Since w have returned from the field, our co versations have not been about the seve ity of the living conditions in the forest even about the strange foods we ate, b about the Aché themselves—their curio ity, humor, strength, and knowledge of th forest and the good times we shared. M Thanksgiving Day in the *monte* was one the best.

Kevin T. Jones is a research assista professor of anthropology and partic pant in the Hunter-Gatherer Researc Group at the University of Utah in Sa Lake City.

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Geoffroy and the Homeobox

The art of finding timeless essences in apparent trifles is the kind of perception that we call genius

by Stephen Jay Gould

As Dickens said about another moment in French history, July 1830 was both the best and the worst of times. From July 27 to 29, known ever since to Frenchmen as *les trois glorieuses,* citizens manned the barricades in Paris and finally forced the abdication of despotic Charles X, younger brother of Louis XVIII. On July 31, on the balcony of the Hôtel de Ville, the aging marquis de Lafayette, America's friend in previous times of trouble, draped himself in the tricolor banner, embraced the duc d'Orléans, and proclaimed him Louis-Philippe, the new, *constitutional* monarch of France.

In the midst of this upheaval, a noted German observer wrote with brimming enthusiasm about a great Parisian battle: "We find in conflict here two such different ways of thinking . . . . It has often happened before in the history of this antagonism, and the phenomenon must occur again and again. . . . When such different elements are forced into contact, where they touch, every time an explosion must result."

The observer, we assume, must have been writing about the age-old strife of monarchists and republicans, then playing its latest version on the streets of Paris. He was not. He described, in these dispatches, an argument then raging in l'Académie des Sciences—"of such great importance," he wrote, "that the history of science may never experience a second example."

The debate, running throughout 1830 in and around the July revolution, featured France's two greatest zoologists as adversaries: Georges Cuvier and Etienne Geoffroy Saint-Hilaire. The observer was no mean journalist: Johann Wolfgang von Goethe. Geoffroy's son, writing later about the great debate, spoke of Goethe's involvement:

> At the very dawn of events that would overthrow a throne and change the face of France, he immersed himself in this peaceful revolution occurring in the pure realm of ideas.

Goethe was no incidental bystander, roped in on a lark. The great poet was also a fine scientist, a student of organic form, and inventor, incidentally, of the word *morphology.* He was also a partisan of Geoffroy's side in the great debate.

This famous struggle, often portrayed quite wrongly as a debate about evolution (which Cuvier opposed to the core and Geoffroy supported in a fitful way), began as an argument about anatomy and ended as an unresolvable conflict between the two most general and irreconcilable attitudes about the nature of organic form.

Geoffroy, a romantic and a dreamer, had a vision—perhaps the boldest, the most noble, the most comprehensive idea ever promoted in biology. As a *pure* morphologist, he sought nature's order in a single abstract plan for all organic design. He maintained, virtually as a motto, "There is, philosophically speaking, only a single animal." (Cuvier, as a *functional* morphologist, denied the utility or reality of such abstractions and argued that an irreducible diversity of form matches the particular functions that organisms perform.)

Goethe hoped against hope that Geoffroy could beat the silver-tongued Cuvier, one of France's greatest orators. For Goethe shared Geoffroy's vision and had, himself, advanced for plants the same general argument that Geoffroy now a vocated for animals.

Goethe's idealistic morphology plants, proposed late in the eighteer century, tried to understand the vari parts, particularly the diverse structu of flowers, by conceiving them as so ma expressions of one underlying, abstra theme that could generate all existing p ticulars through a set of geometrical tra formations. For Goethe, this ideal sou was the leaf itself.

Geoffroy applied the same vision to a mals, arguing that vertebrae could p form for moving things the same role t Goethe ascribed to leaves as the foun tion of form in plants. The dream that apparently overwhelming diversity mig be reduced to one underlying generality a foundation sought not in the mechani terms of physics and chemistry but in ideal realm of pure form—motivated b men.

But scientific visions, no matter how ble, are only as good as their evidence and Geoffroy proposed an elaborate se hypotheses to affirm his claim that a mals are built as repeated and modif vertebrae. He sought to establish a hom ogy—that is, a true similarity based common origin, rather than a mere an ogy or likeness developed independen by two groups in response to shared fu tional needs—between the complete s mentation of insects and the partial re tition of vertebrates (seen primarily in vertebral column and paired ribs).

Such a proposed homology between segments of an insect's *external* skele and a vertebrate's *internal* spine lead some mighty peculiar comparisons, if

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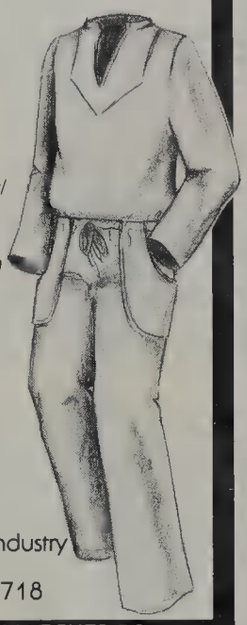

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pledge to follow the basic model in a forthright and rigorous way—as Geoffroy certainly did. He wrote in 1822, with a firm assurance that others will interpret as bold or foolhardy according to their prejudices:

> I have never ceased to follow nature's great thought: the unity of organic composition; and, in the confidence that this fundamental truth has given me, I must grasp my problem in its greatest generality, approaching each part not with hesitation, but moving on the contrary with sureness.

Two comparisons, particular, struck most biologists as especially hard to swallow and helped to seal Geoffroy's fate. First, if the bones of a vertebrate's spine are homologous with external segments of insects, then insects must—quite literally—live *within* their own vertebrae. Geoffroy wrote in 1822: "Every animal lives outside or inside its vertebral column" (*Tout animal habite en dehors ou en dedans de sa colonne vertébrale*). Second, if the paired attachments to all "vertebrae" are also homologous, then the legs of insects are the same structures as the ribs of vertebrates—and insects walk on their ribs.

Since pictures are so often worth the proverbial thousand words, consider as an expression of Geoffroy's bona fides his illustration of a lobster's segment, published in 1822. Note the subtle positioning and proportions that make the lobster's external girdle look so much like a large vertebra with a substantial hole in its center for living tissue, while the legs bend and begin to wrap forward like a pair of vertebral ribs.

The comparison of insect and vertebrate caused difficulty enough for Geoffroy's vision of organic unity. But he wanted more and went further, provoking Cuvier's ire and his own downfall. Early in 1830, two of Geoffroy's young disciples tried to extend the grand homology by arguing that cephalopods (squids and their allies) are built as vertebrates doubled back on themselves, thus bringing the great phylum of mollusks (including such overtly unsegmented creatures as clams and snails) into line with arthropods and vertebrates.

This was too much for Cuvier, the pre-eminent functionalist who understo that the strong similarities between squ and fish were analogies independen built as good, hydrodynamic solutions the problems of swimming. The great bate had begun.

Goethe, from the sidelines, rooted Geoffroy, but most observers scored t match as a decided victory for Cuvier though debates of such abstraction are simply "won" or "lost" in conventio terms). And so history has judged this rious event. In our current classificatio complex animals are divided into two m jor branches, the protostomes (includi insects) and the deuterostomes (includi vertebrates)—and never the twain sh meet. As a graduate student in system ics twenty years ago, I learned no tru with greater assurance than the propo tion, proved by Cuvier against Geoffr that the full and complete segmentation arthropods has no homology with the li ited and imperfect segmentation of ver brates, confined primarily to muscles the trunk and their associated skeletal a nervous systems. Geoffroy's vision unity in organic design died 150 years a

But big ideas developed by great thi ers rarely disappear completely. Few m of vision are so profoundly wrong that motivating dream of an intellectual li time contains nothing worthy of later tention, often in an intriguingly alte form. Sure enough, last year's bigg news in developmental genetics exhum Geoffroy's old vision of homology tween the segmentation of arthropods a vertebrates (although I have been ast ished that no one, in scores of primary a cles and secondary reports devoted to subject of the so-called homeobox, drawn the obvious connection with Ge froy's ancient vision). The story, as shall see, is particularly interesting cause a superficial interpretation of "homeobox" revives Geoffroy's dream its overt form. We shall see, however, t this interpretation cannot stand—but t victory may yet be snatched from th jaws of Geoffroy's second defeat to aff something deeper about his curious, profound, vision.

In the fruit fly *Drosophila,* best kno

From Mémoires du Muséum d'Histoire Naturelle, *1822*

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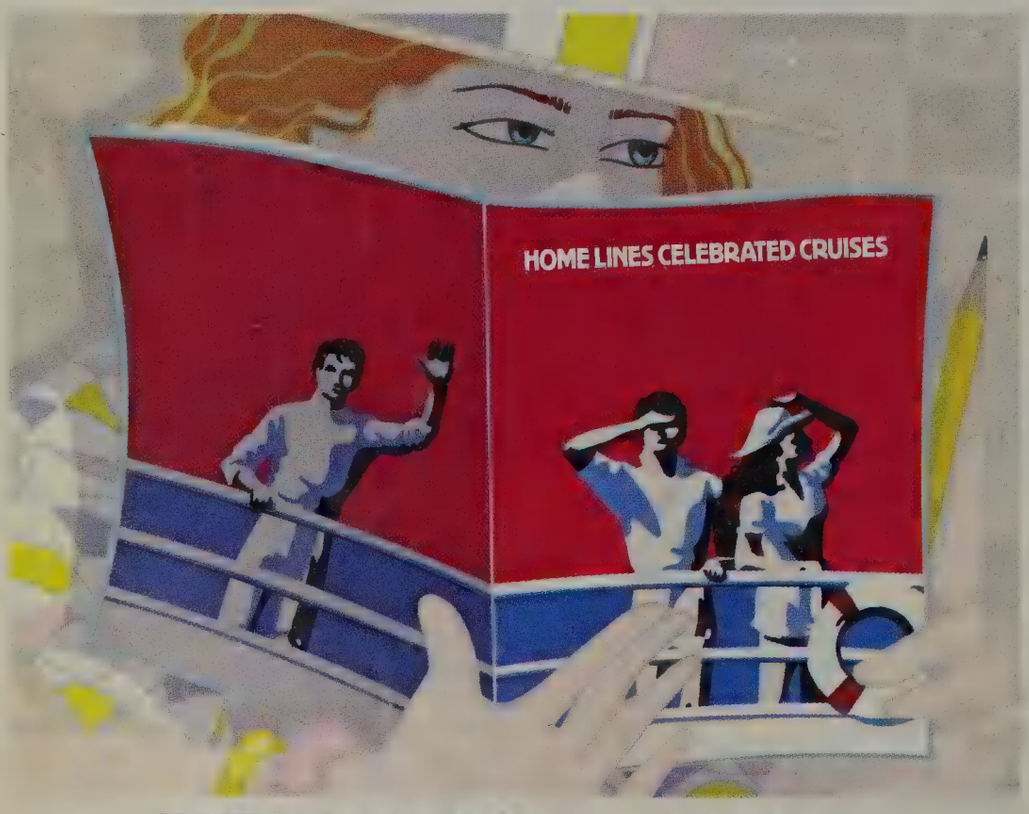

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of all complex animals in genetic term differentiation of segments (why some d velop mouthparts, others wings and leg still others abdominal structures) falls u der the control of two gene complexes l cated on the right arm of the third chr mosome. Each complex contains sever genes. The antennapedia complex (calle ANT-C for short) influences anterior se ments of the head and thorax, while the b thorax complex (BX-C) works upon th fly's rear end, from the back part of th thorax through the numerous abdomin segments. Well-known mutations in se eral of these genes have the peculiar pro erty of placing normal structures in th wrong places. (In the namesakes of th two complexes, flies with the *antenn pedia* mutant grow legs where their ante nae should be, while *bithorax* individua develop a second pair of wings in oppo tion to their own name—flies are Dipter or two-winged.) Such mutations, repla ing expected organs with homologo parts that should develop in other place are called homeotic, a term coined early the century by William Bateson, who al gave genetics its name. (See my column October 1980 for more information homeotic mutations.)

Early in 1984, molecular geneticists a nounced a remarkable discovery abo the fine structure of three genes in the homeotic complexes. We are living in t midst of a revolution in technique with genetics that is spilling into public atte tion via debates about genetic enginee ing. The methods of research in so-call recombinant DNA have permitted us learn, in a routine way, albeit with a va amount of hard work, the sequence base pairs that builds the genetic mater of DNA. We can, in other words, now re the detailed structure of genes.

A very short region, only 180 base pa long and located within the *antennaped* gene, showed such remarkable similari to a unit of identical length in anoth gene of the antennapedia complex (call *fushi tarazu,* or "futz," for short, amo the cognoscenti) that both must share common evolutionary origin—the simila ities are too complex and detailed for ind pendent evolution under similar co straints of function (see my column April 1985 for an explicit discussion when and why detailed molecular simil ity must record homology, or unity of ev lutionary origin). Soon afterward t same short sequence was detected in gene of the other homeotic complex, *trabithorax* of BX-C.

This short, highly conserved sequen received the name homeobox because was first found only in genes of t

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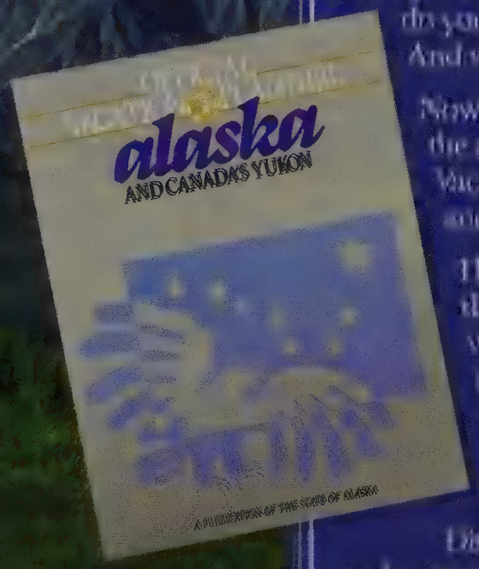

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homeotic complexes and because its trim, tight composition of but 180 base pairs suggested a discrete unit (a "cassette," as one discoverer wrote) that might be copied precisely and inserted into various parts of an organism's genetic material.

This discovery provoked a search for other copies of the homeobox within *Drosophila* genes. The work continues, but a recent report (a review by W.J. Gehring in *Cell,* January 1985, pp. 3–5) mentions more than ten additional genes containing homeoboxes. The homeotic complexes have emerged as preferred "homes" for this conserved sequence—five genes of ANT-C, and three within BX-C, contain homeoboxes. The copies found outside the homeotic complexes lie in genes that also seem to code for some aspects of spatial organization in the embryonic segments.

The homeobox first inspired excitement because it seemed to confirm a long-standing hypothesis about the evolutionary origin of the homeotic complexes. Ed Lewis of CalTech, world's expert on the homeotic genes of *Drosophila,* had proposed that the many genes of BX-C (at least eight), arrayed in linear sequence along the right arm of the third chromosome, arose as repetitions of a single ancestral gene (see my column of November 1981 on the ability of some genes to make copies of themselves and move to new positions). The presence of such a highly conserved, shared sequence within so many homeotic genes provides strong support for Lewis's theory (an alternative, or complementary, idea might hold that only the homeobox cassette duplicates and inserts itself in new places).

The simple existence of such a highly conserved sequence in so many places provided enough excitement, but the story goes deeper—thus forging the link to Geoffroy's old vision. (I should say at the outset of this linear account of events that I am not describing discoveries in their chronological order but in a logical sequence of my own construction that allows me to make sense of much fine work, proceeding in several laboratories and cascading simultaneously in many directions. All these discoveries occurred or were published during 1984—a good sign of how quickly an exciting field can move.)

The presence of so many copies throughout the *Drosophila* genome does not prove that the homeobox does anything important for the organism (some repeated elements may act as "selfish DNA," able to replicate, move, and insert, but performing no function for the larger organism containing them—again, see column of November 1981). An argum for function must first determine whet or not the homeobox gets transcribed i RNA and then translated to protein or zyme—and the link to Geoffroy's vis requires a hypothesis of function. Mu DNA is silent, or untranscribed, much may be junk (so called) with ref ence to its utility for organisms.

The homeobox is, in fact, transcrib and translated—so this basic argum for function holds. Since DNA is a trip code, the 180 base pairs of the homeob produce a so-called homeodomain of amino acids. The strongest argument important function rests upon the disc ery that this homeodomain (the 60 am acids) is even more highly conserved th the parent homeobox (the 180 base pa of DNA). The foregoing statement m seem puzzling—that higher amino a than code similarity indicates functio meaning for a stretch of DNA—but justification arises from the nature of DNA code.

The genetic code is, in technical p lance, "redundant" at the third positio most cases—that is, the first two b pairs of any triplet determine the am acid that will be translated, while the th

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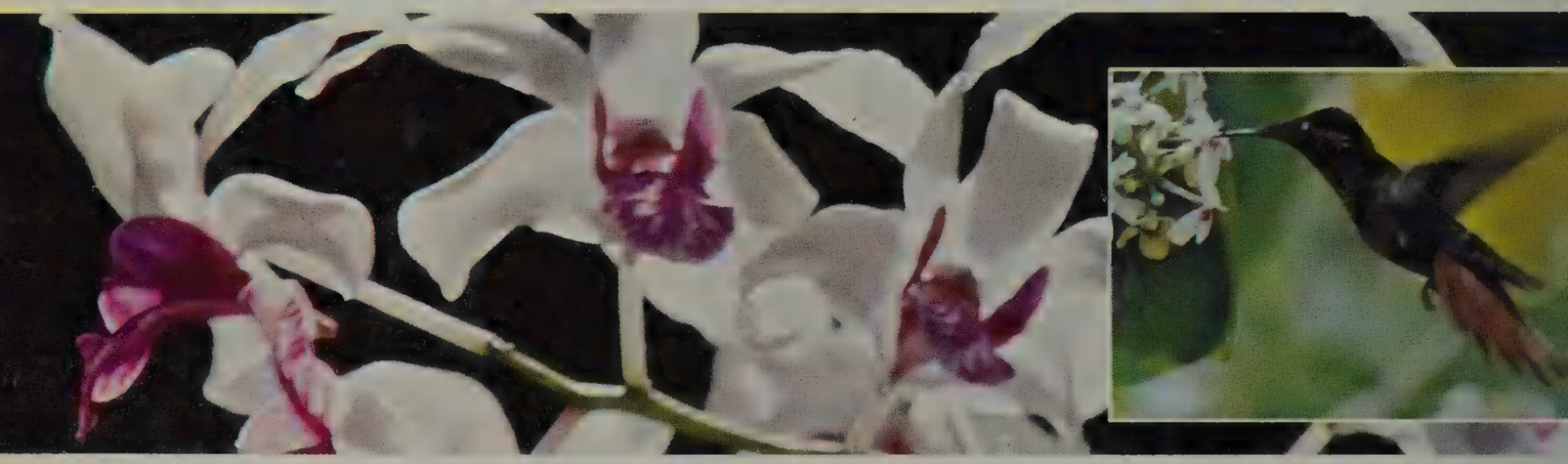

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tion can often be occupied by any of possible base pairs and still yield the e amino acid in translation. Thus, any ation at the first or second position will se the translation of an altered amino l, but third-position mutations are usu- "silent" because they induce no nge in the product—the amino acid— the organism sees and uses.

Now, the homeodomain is substantially e similar among its several copies than homeobox that codes for it (for the copies discovered in *Drosophila,* ho- box similarities ranged between 75 79 percent of base pairs, while homeo- ain conservation rose to 87 percent of no acids). The basis of this difference t be—and indeed is, as we now know n direct sequencing of the base pairs amino acids—that many silent muta- s accumulate among the different ies of the homeobox to drive their over- similarity down, but that something is tly conserving the amino acid se- nces by rejecting first- and second-po- n mutations that change the structure function of proteins but permitting "invisible" silent mutations to accu- ate in third positions. That something t be natural selection, operating to serve the protein structure of the ho- domain. If natural selection is work- so assiduously to conserve the homeo- ain, then its protein must be doing ething right for the organism—it t, in other words, perform an impor- t function. (The comparison of silent us translated mutations is a standard for function in molecular genetics, not w argument developed for the homeo- story.)

Thus, we know that the homeobox oc- s in several *Drosophila* genes, mostly he homeotic complexes, and that it es for a protein with important func- s. But what does this protein do? At t glance—but please remember that t glances can be dangerously simplis- —we might be tempted to conjecture t the homeobox is a key to the control l expression of segmentation. Why else uld its copies lie in genes of the home- complexes and rarely elsewhere?

We might gain further clues about ction of the homeobox by scanning er organisms to see where it does and s not occur. Initial results on other in- tebrates might be viewed as enhancing suspicion that homeoboxes are regula- s of segmentation. The homeobox se- nce has been found in other species of *osophila,* in *Tenebrio molitor* (a bee- , and in an earthworm of the genus *mbricius*—all segmented animals. It not been detected in a nematode, a sea

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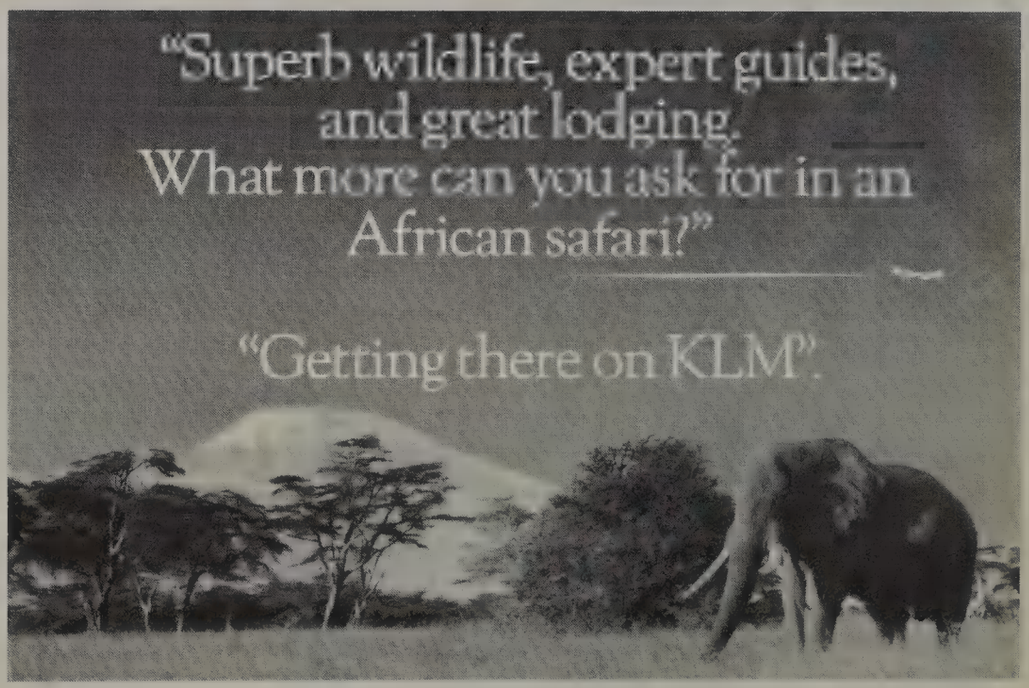

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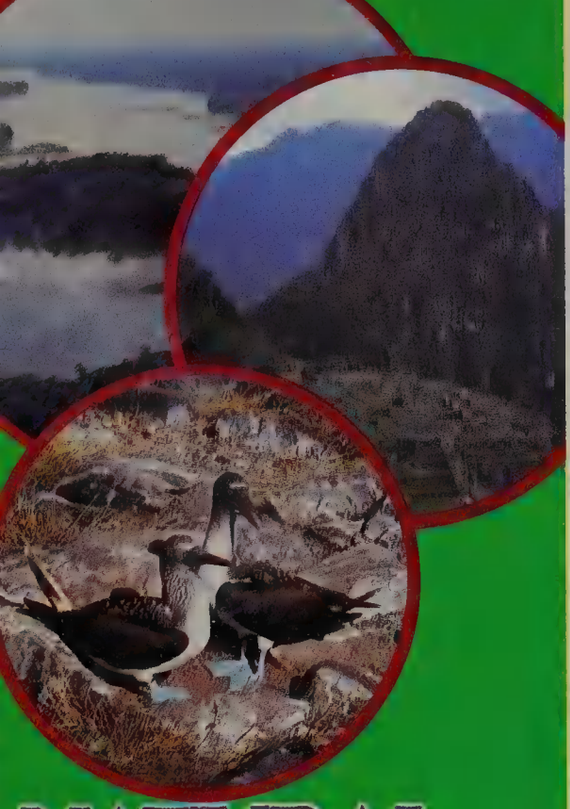

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urchin, and the bacterium *E. coli,* all unsegmented creatures (see W. McGinnis and others, *Cell,* vol. 37, 1984, pp. 403–8).

But the biggest surprise, and the source of popular appeal for the homeobox, arrived with its discovery in yet another group of organisms—our own. If *Drosophila* is the standard invertebrate of laboratories throughout the world, the South American toad *Xenopus* has been granted this dubious distinction among cold-blooded vertebrates (mice play the part for mammals). Inevitably, geneticists turned their search for homeoboxes upon *Xenopus*—with success. Homeoboxes have been found, so far, in two *Xenopus* genes. (Our knowledge of vertebrate development is so poor that we do not know, for certain, how any single gene operates to regulate the position or differentiation of structures in embryology. But we have some pitifully preliminary hints that the homeobox-containing genes of *Xenopus* may play some role in development. One gene, for example, produces RNA transcripts in egg cells and again at the crucial stage of gastrulation in early embryology—where the transcripts might be translated to proteins involved in the determination of embryonic cell types. (See Müller and others, *Cell,* vol. 39, 1984, pp. 157–62.)

The similarity between these *Xenopus* homeoboxes and those discovered earlier in *Drosophila* is startling. The homeodomain of one *Xenopus* gene is identical to the corresponding homeodomain of *antennapedia* in *Drosophila* at fifty-nine of sixty amino acid positions! This frog–fly concordance is far stronger than the similarity between the two frog homeodomains (fifty-four of sixty amino acids, with twenty-three silent third-position mutations in addition), or between any pair of homeodomains within *Drosophila.* Something is working awfully hard to conserve this similarity across one of the most profound phylogenetic gaps in the history of life (the common ancestry of insect and vertebrate predates the establishment of our adequate fossil record in the Cambrian explosion nearly 600 million years ago).

Further scrutiny then revealed homeoboxes in other vertebrate genes. A gene on mouse chromosome 6 contains a homeobox with a 66 to 70 percent base pair similarity to *Drosophila* and 66 percent to *Xenopus* (W. McGinnis and others, *Cell,* vol. 38, 1984, pp. 75–80). Two human genes also sport homeoboxes, yielding an average of 90 percent amino acid similarity with the three homeodomains first discovered in *Drosophila* (see Levine and others, *Cell,* vol. 38, 1984, pp. 667–73).

As discovery cascaded upon discovery many scientists and commentators aske what common theme lay behind these ob viously interrelated observations. An in triguing possibility inevitably bubble forth: homeoboxes are primarily found i genes that regulate the differentiation o segments in *Drosophila;* they are als present in other segmented invertebrate and absent from unsegmented creature Vertebrates also have homeoboxes and a least some form of imperfect segmenta tion. Of course, we had all learned tha segmentation in insects and vertebrate can only be analogous—a product of inde pendent evolution in lineages long sepa rate. Or must segmentation be only anal gous? Could it possibly be homologou after all? The homeoboxes of insects an vertebrates are clearly homologous. they regulate segmentation . . . well, the by God, could Geoffroy have been righ all along and after all (following 150 yea of calumny and the kind of dismissal tha so erased his name from the history of sc ence that not a single geneticist remem bered this link with the past while so man discussed the potential homology of seg mentation)?

Press reports poured forth. Some bega to speak, in overblown terms, about th Rosetta stone of development, biology greatest mystery. Scientists tended to b more cautious, but several floated the h retical idea of homology for the segment tion of insects and vertebrates—Geo froy's common ground plan of anim development. W. McGinnis and co leagues wrote, for example (*Cell,* vol. 3 1984, p. 679):

> If the conserved homeodomain in fruit flie frogs, mice and humans is involved in th control of segmental development, then it possible that the segmentally organized an mals in both the protostome and deuter stome classes had a common ancestor, an that the metameric body plan has evolve only once in metazoa. [Metamerism refe to the complete segmentation of arthr pods; metazoa are the multicellular an mals.]

This explicit vindication of Geoffroy r mains a possible interpretation of the h meobox, but proper caution has begun replace overextended enthusiasm, an other less flashy (but in many ways mo intriguing)—and, I suspect, more prob ble—explanations have now been offere

The superficial interpretation—if it's homeotic genes and homeotic genes reg late segments, then it must regulate se ments—is logically flawed, in fact one the classically false syllogisms of bas courses. We might as well argue th sneakers produce a high field-goal pe

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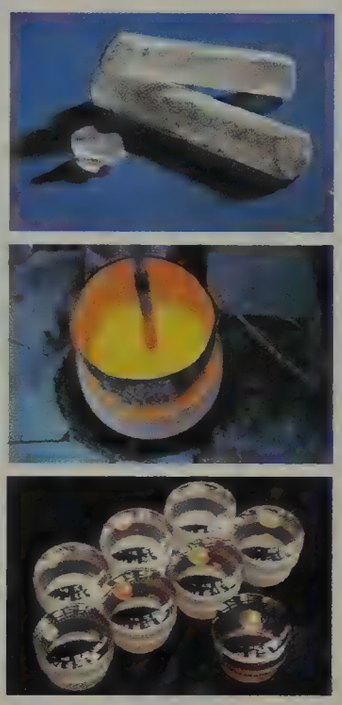

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centage because all great basketball players wear them.

Sure, the homeobox performs an important function, and (from the genes chosen as bedfellows) it probably has something to do with the embryology of spatial organization. But why should that something be the actual control of segmentation itself (the only argument that would affirm Geoffroy's vision in its explicit form)? Think of the more basic activities that genes must superintend before we can even talk about such overt morphological phenomena as segmentation (just as basketball players have to cover their feet with something before they can display any fancy artistry with drives and jump shots)—particularly the production of proteins in the right places, at the right times, and in the right amounts. Perhaps the homeobox works for one of these deeply basic functions acting as a vital prerequisite for anything so much later (in a causal chain) and so much more specific as segmentation.

My friends Elizabeth C. and Rudolf A. Raff (*Nature,* vol. 313, 1985, p. 185) have suggested such a more general and more "mundane" (their word) function for the homeobox. Translation of RNA to proteins occurs in the cytoplasm. But proteins that will act as basic regulators of development by turning other genes on and off must get back into the nucleus (where the genes reside on their chromosomes). Perhaps, they suggest, the homeodomain simply acts as a "nuclear tag," attaching to other regulating proteins that must enter the nucleus and, perhaps, facilitating their entry. I do not know whether this hypothesis has any validity, but it represents the *kind* of proposal more likely to prove useful than the superficially attractive idea that homeoboxes build segmentation directly.

In fact, we have some hints of evidence for more basic function. Homeoboxes have also been found in two of the so-called mating-type genes of yeast—genes that seem to control the stable determination of cell types in these organisms. Now yeast, obviously, are not segmented. (This argument, however, does not preclude the notion that homeoboxes regulate segmentation in insects and vertebrates. After all, the homeobox didn't arise mysteriously from nothing. It must have developed from some precursor in an ancestral unsegmented organism. This ancestral proto-homeobox may have worked in one way for ancestors and then been co-opted as a regulator of segmentation in descendants. I discussed the important evolutionary principle of such quirky shifts in function, known to biologists by the awful and senseless name *preadaptation,* in last month's column.)

We may, however, read the discovery of homeoboxes in yeast in a more positive light, not as a problem to finesse in preserving the hypothesis that homeoboxes regulate segmentation, but as overt support for the conjecture that homeoboxes perform a more basic function common to yeast and segmented organisms—some primary control in the differentiation of cell types, for example.

An intriguing hint in this positive direction comes from the apparent homology between proteins coded by the yeast mating genes and proteins in bacteria that may perform the most basic regulatory activity of all—binding to DNA. (If some genes work by regulating the turning on and off of others, then their products—proteins—must be able to bind with the DNA of other genes.) Could the homeobox code for such a central protein function as DNA binding? Such a utility would represent function at the most basic level of organic construction—a role far more general than the production of segments. By the time segments form in insects and (imperfectly) in vertebrates most of what really matters in the regulation of development has already occurred.

So where does this claim for function more general than segmentation leave Geoffroy's dream of a common ground plan for all organisms? Just when his most radical notion of homology between segmentation of insects and vertebrates seemed on the verge of revival in molecular form, along came all the naysayers and doubting Thomases of biological caution to point out that presence of a homeobox in a homeotic gene doesn't mean function *for* segmentation. These modern Cuviers, it seems, have again crushed the dream of unity after such a short and fitful flicker. Or have they?

What was Geoffroy really after? He had a vision of unity and he expressed it in the deepest and most general terms that his century knew—the generating rules of overt morphology. But Geoffroy dreamed of something deeper than external form—some underlying basis that would produce similarities of form as a necessary and superficial expression of its work. Indeed, though he invoked form *faute de mieux,* Geoffroy always sought a deeper unity that would generate form as a product. After comparing the segments of a cow and a crab, he wrote in 1807: "I have insisted upon an identity which has extended to the least important relation of all, that of form." And toward the end of his life, following his rout by Cuvier, he wrote in 1835:

ve, moreover, regenerated this principle
y of plan and composition], and ob-
ed for it universality of application, by
ving that it is not always the organs as a
le, but merely the materials composing
organ that can be reduced to unity.

n other words, Geoffroy dreamed of a
y deeper than the homology of overt
nentation, which he viewed only as the
empirical evidence he could find—
closest approach that techniques of his
e would permit to the underlying basis
mystery of development. Somewhere,
rever good biologists go, I think that
ffroy's spirit is now rejoicing that the
eobox may unite insects and verte-
es in a developmental unity more ba-
than their final forms—and that the
t general rules regulating the conver-
of DNA code to adult organism may
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ory. There must be "unity of plan and
position" at some higher level that
scends the simple and obvious identity
hemical building blocks.

o perhaps Goethe was right after all to
re the tumultuous events in the streets
Paris and to argue instead that an ab-
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nces had far more ultimate impor-
ce in human history.

he art of finding timeless essences in
arent trifles, and ignoring contempo-
, engulfing tumults as ephemeral,
ks the kind of perception that we call
ius. Umberto Eco has captured this vi-
heme as the centerpiece of his wonder-
mystery novel, *The Name of the Rose.*
liam of Baskerville, that medieval
rlock, is surrounded by the portentous
nts of his century, particularly the dis-
e between the papacies of Rome and
gnon. But he solves the abbey murders
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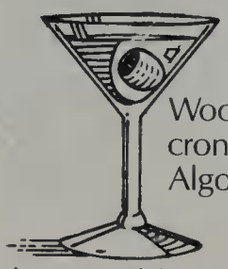
nderstands that these doings, however
eloping, will pass and be forgotten—
that the only important object in the
g run, however invisible to all others
dst such tumult, is the library's copy,
only in existence, of a potentially anti-
istian work of Aristotle. Goethe had
priorities straight as well—and the
a of his dying words rings through the
s: *Mehr Licht* (more light).

*phen Jay Gould teaches biology, geol-
, and the history of science at Harvard
versity.*

"I MUST GET OUT OF THESE WET CLOTHES AND INTO A DRY MARTINI."



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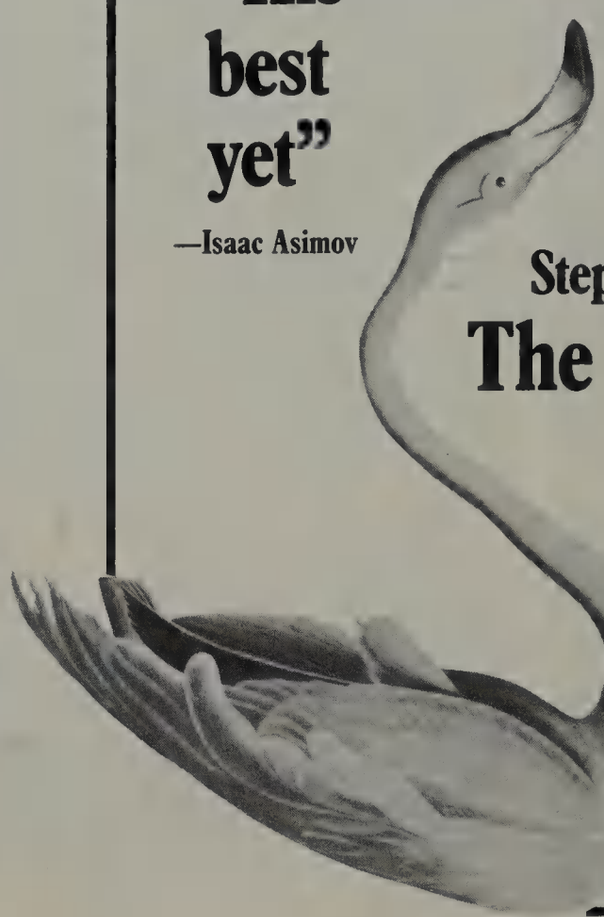

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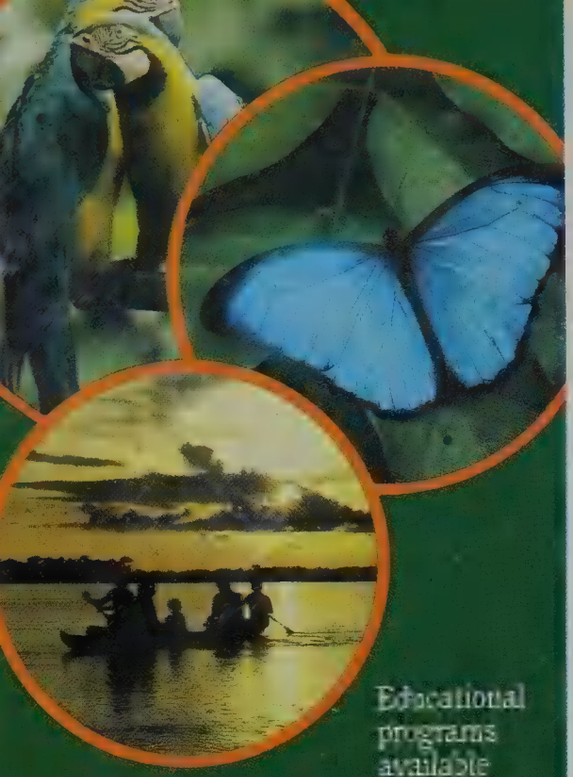

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Good Scents And Bad

Odors can be a mammalian aphrodisiac or a turnoff

by Adrian Forsyth

My wife smells smells that are lost on me. Just yesterday she sniffed out a tree, a tropical tree some hundred yards away, exclaiming the power of the scent. I smelled nothing until I pushed one of the deep, creamy white blossoms flush with my nose and then detected only a mild, musky smell. It is the same when we go mushrooming: she is always the first to guess that there are stinkhorns about, readily reading their rank signature on the wind. Stinkhorns are dramatic mushrooms (with names like *Phallus impudicus*) that rise from the soil in a form so true to their name it is scarcely credibl They reek rottenly, baiting the stick footed flies that will disperse their spore The difference in olfactory acumen b tween my wife and myself has nothing do with, say, the considerable differen in the size of our noses. It is simply ma and female in its division.

Women can smell some scents that m are only dimly aware of. It is probably accident that the tree I mentioned reg tered on my wife's nasal nerve endings a not on mine. It is pollinated by bats, a like most bat-pollinated flowers, its sce is a heavy, musty musk. Musk, of cours is a male-generated scent. The comme cial musk of perfumes is milked fro mammal glands. It is, or used to be, a se

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Fran Allan; Animals Anim

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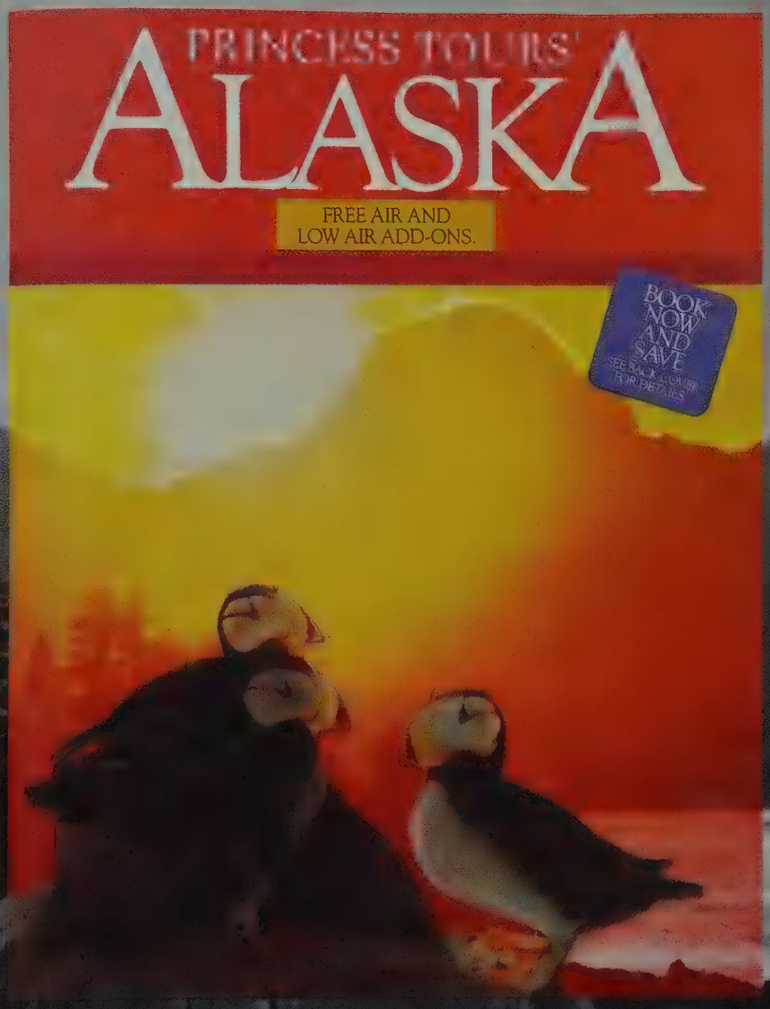

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ual signal, a fact that may or may not be appreciated by perfume purchasers. Eugene Marais, the visionary biologist who wrote *The Soul of the White Ant* and *The Soul of the Ape*, commented: "Ask a young woman why she uses the heavenly perfumes the chemist of our day has learned in such exquisite perfection. Her answer will be misleading, because she does not know the subconscious reason. . . . She would be embarrassed if she learned the bases of all her perfumes were the sexual secretions of several kinds of cats, a deer, and (the most expensive of all) the rudimentary sexual material secreted by a certain kind of whale. . . ."

The human male gives off scents that are chemically related to the chemicals controlling masculinity, androgen hormones such as testosterone. One famous experiment comparing olfactory sensitivities of males and females to various chemicals showed that women are one hundred times more sensitive than men to exalotide, a compound similar to male sexual musk. This sensitivity peaks about the time of ovulation. It can be completely extinguished if a woman has her ovaries removed, and it can be restored by injections of the female sex hormone estrogen.

Sexual scent signals are widely used by other mammals. In some species a whiff of a single chemical compound is enough suddenly induce sexual interest in male female. If a female dog, one not in estru is dabbed with methyl p-hydroxybenz ate, all the male dogs in the vicinity a immediately aroused into harassing h with vigorous sexual advances.

Mammals are well known for their u of smells and tastes to signal their sexu status and for their ability at reading a testing olfactory information about oth animals. Many large grazing ungulates- camels, horses, deer—either sniff or dri the urine of females. They swill it in the mouths and draw back their lips and no trils in a characteristic grimace, a postu thought to increase sensitivity in the sam way wine tasters swill wine about in the mouths to increase the reading of its fl vor. These tastes enable a male to asse the female's reproductive conditio Males may also give off scents. Billy goa for example, will urinate and even ejac late into their goatees, a practice that co tributes to their goaty odor and that mu convey information on their sexual rea ness. White-tailed deer bucks will ejac late on the ground and wallow in the ejac late for presumably similar reasons, a other mammals, such as porcupines, u nate on their paws and present them females. Rabbit males may leap over t

David C. Fritts; Animals Anim

A male bighorn sheep tests the reproductive condition of a ewe.

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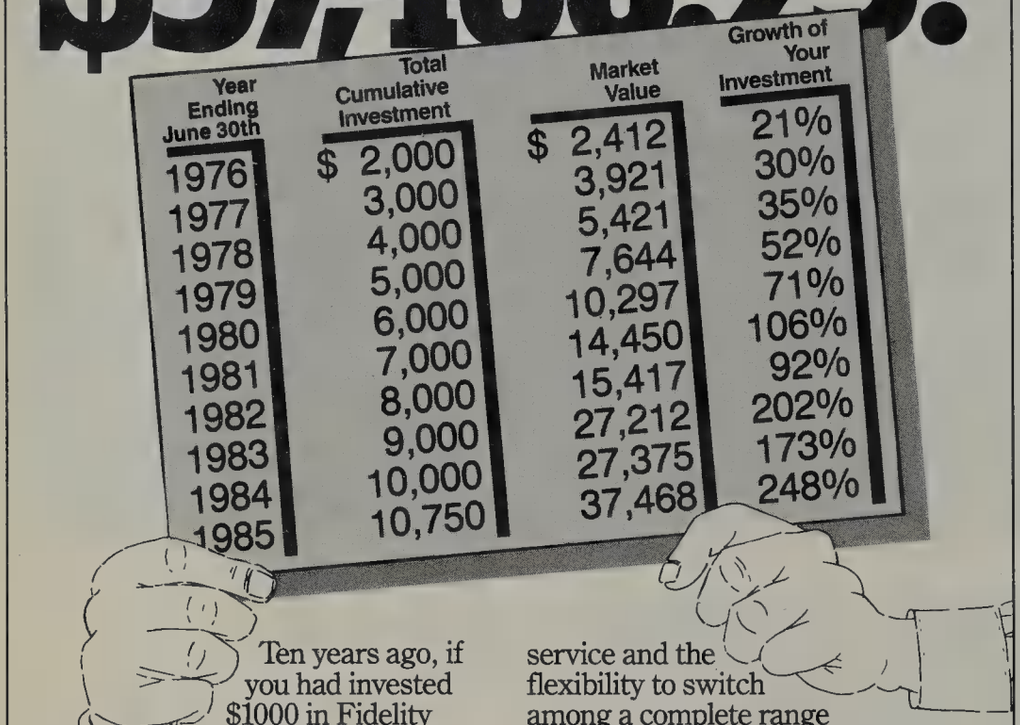

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females, urinating on them as a regular feature of courtship.

My farm and ranch equipment catalog offers aerosol spray cans labeled Boar Mate. Farmers can spray their sows into lordosis, the posture and attitude needed for boars to be able to mate with them. The compound in the can is androsterone, again the close relative of the sexual pheromones of humans. Androsterone was first found in human urine some thirty years ago. It is also excreted by apocrine glands in the region of the armpits and groin and seems associated with the tufts of hair growing there, as a kind of broadcasting system. There is a remarkable twist to the story of androsterone, which hogs of both sexes exude in their saliva. The same compound is given off by truffles, perhaps to attract vertebrates that eat them and disperse their spores. That is undoubtedly why hogs are such excellent truffle finders and perhaps why people are willing to pay outrageous sums for a whiff of their dank (to my mind), fungal flavor. But before you rush off to buy a can of Boar Mate for your own sexual experiments, you might consider that some women from Britain's Royal Shakespeare Company who participated in a study of androsterone (in the choice of unsprayed and sprayed seats) had their menstrual cycles disrupted. And anyone in the vicinity of swine ought to be especially cautious.

On the other hand, the odor of truffles and androsterone may have little effect on human sexual behavior. Shakespeare has King Lear saying, "Give me an ounce of civet, good apothecary, to sweeten my imagination." And some cosmetic firms have taken to selling colognes and cosmetics containing androsterone. But quantifying the effect is difficult. A few of the tests attempting to bioassay an effect of androsterone border on the bizarre. Some purport to show that seats sprayed with androsterone are more attractive to women than to men. In another study, both males and females rated photographs of women as more attractive when observers were exposed to androsterone. One test that failed to find any sweetening had students reading an erotic piece of literature while breathing through a mask containing either androsterone or a control rose water solution. Needless to say, *no* arousal was detected. Similarly, a study published in the prestigious journal *Science* with the unusual title "Changes in the Intensity and Pleasantness of Human Vaginal Odors During the Menstrual Cycle" reported that the intensity of vaginal odor declined as ovulation approached and that the male and female subjects both found the odor less pleasant at that time. The in

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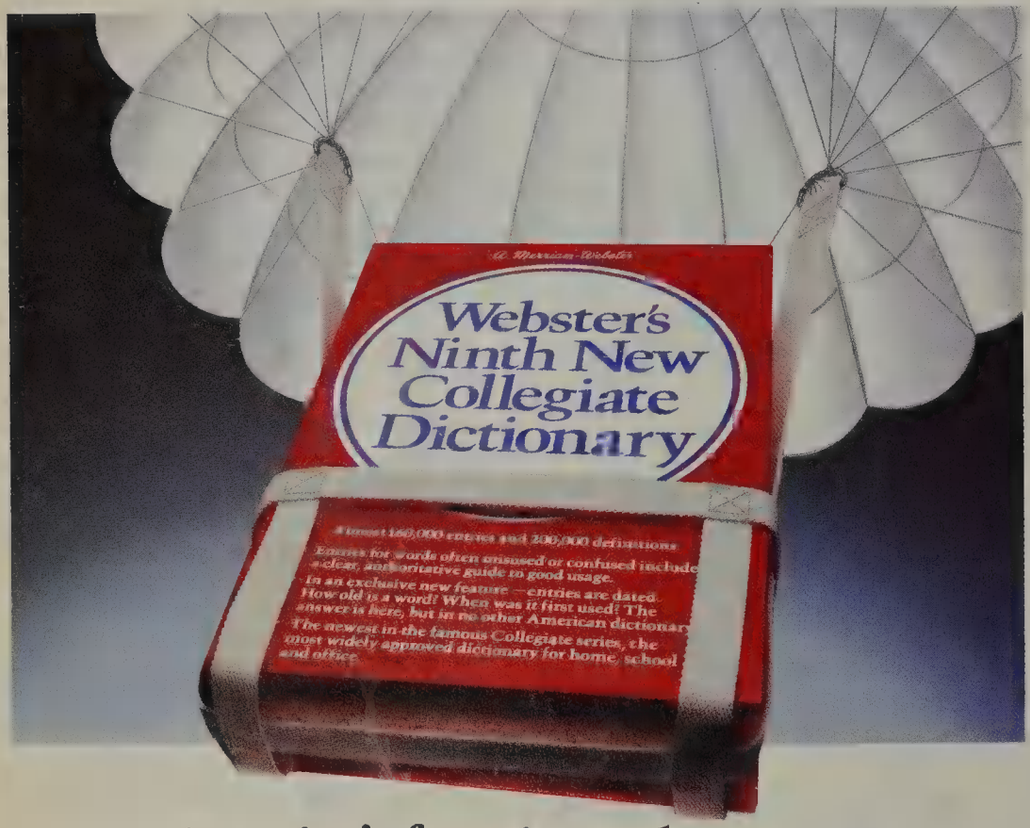

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vestigators concluded that the data "do not support the notion that such odors are particularly attractive to humans in an *in vitro* test situation." That last phrase means that sniffing vaginal swabs while sitting in an air-conditioned room is not a particularly enjoyable task.

Human vaginal odor involves at least thirty compounds derived from (1) vulvar vaginal secretions from sebaceous sweat and Bartholin's and Skene's glands, (2) mucus from the cervix, (3) compounds from endometrial and oviductal glands, (4) transudate from the vaginal walls, and (5) exfoliated cells of the vaginal mucosa. Any or all or these components may produce or provide substrates from bacterial production of volatiles. Taken out of their natural context, such strong and complex odors are no more likely to be perceived as pleasant than a whiff of Limburger or anchovy paste, fragrances that many find extremely appetizing in the right place. So it is impossible to say whether there are any data indicating a pheromonal, attractive excitatory role of such odors. The literature of human emotions certainly contains much anecdotal evidence in favor of the idea. That is why attempts by cosmetic corporations to patent and market human pheromones continue. Reportedly, the fatty acids in vaginal secretions, known as copulins, have been patented but not commercially marketed. This may not be so much because of their somewhat fishy smell as because these compounds are capable of attracting the attentions of monkeys, billy goats, and other inappropriate mammalian suitors. But whether or not they will do anything to human males is unproved.

Our continued use of perfumes suggests that there is some olfactory component to our sexual interactions. What is surprising is how different modern perfumes are from what must have been the ancestral perfumes, the oozes of glands and orifices still used by mammals. It is strange that we still sprout armpit hairs, which like the hair pencils of moths, exude a scent most efficiently through the huge evaporative surface area of hundreds of bristles. But that scent is not marketed; indeed it is now almost everywhere an anathema.

Olfactory coercion, the strong bending the will of the weak through the sense of smell, is a specialty of rats, mice, and many other social rodents. As social mammals, they may give us some insights into the forces, even if they are now irrelevant, that were responsible for the evolution of menstrual synchrony. Rodents are especially sensitive to the scent signatures in urine, and they adjust their reproductive state according to what they read. Juve

e female house mice that are exposed to urine of males will reach estrus twenty ys before unexposed females. If an ult female mouse is exposed to the urine a male, within twenty minutes her erus weight begins to shoot up and her productive hormones are triggered into tion. In prairie voles this effect is so pro-unced that the weight of the female erus doubles in two days. On the other nd, if more than one female is present, e effect is reduced. When male urine is esent, female urine will inhibit estrus by ven days; if there is no male around, the hibition will last as long as four weeks. ne effect also operates on males. Urine om females accelerates male maturation hile that from other males inhibits it. nder natural ecological conditions, this eans a mother is able to suppress the re-oduction of her daughters until she dies. nd daughters or groups of females in-bit each other reproductively.

Biologists have shown that the urine of male Norway rats contains two different rborne cues that tend to cause menstrual nchrony within the social group. One ne shortens the cycle and enhances the obability of coming into estrus; the her suppresses estrus and lengthens the cle. Dominant and subdominant females may differ in the proportion of the two chemical cues they produce. Subdominants may signal their submissiveness as the payment for freedom from attack by producing the accelerating pheromone, while dominant females may produce the suppressing compound. And male urine ought to attempt to chemically countermand these signals. Male urine should be designed to bring as many females into estrus as fast as possible.

We know that male urine can influence female reproductive physiology to the female's detriment via the famous Bruce effect, named for Hilde Bruce. She discovered that if pregnant mice are exposed to the urine of a strange male, the embryos are either not implanted or are spontaneously aborted. This is another form of male infanticide whereby a male destroys the offspring fathered by another male and attempts to bring the female back into estrus, ready as a receptacle for his own genes. At first, this seems to be totally maladaptive from the female's point of view. Yet it may be a way for her to minimize her loss of investment. If the new male owner of the territory will destroy her offspring (as males do in takeovers of monkey and lion troops), then she can cut her losses by aborting immediately. Nevertheless, she still suffers as a result of the infanticidal male strategy.

Sympathizers of female rodents will be gladdened by the way the olfactory acumen of female brown lemmings influences male behavior. Females can smell success. Male brown lemmings often fight for access to females, and apparently the outcome of their battles influences their attractiveness. When females are given a choice between winners and losers (both still capable of mating), they choose winners, and they do so by use of their noses. They can distinguish between winners and losers within five minutes, an hour, or a day after the fight. Aggressiveness is important for lemmings, which periodically undergo intense crowding as a result of exploding populations. And since it is a heritable characteristic of many rodents, there is probably some value for females in choosing winners over losers.

Rodent smells are not merely urine. Beavers, for example, produce pheromones containing more than fifty different molecules. Variations in the concentrations of this many components make it possible for every individual to have a distinctive olfactory signature. This enables various rodents to recognize individuals and even to avoid incestuously mating

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Jim Brandenburg

Are smells the guideposts that lead salmon from oceans to spawning grounds?

with individuals whose odor signifies they are too closely related.

These seem like valuable abilities. But textbooks tell us we humans have abandoned them; our sense of smell has grown superfluous while our eyes have grown keen. Yet I think it is too soon to abandon the idea that human odors might not influence human behaviors. Smell may still be bound strongly to unconscious imprinting and memory associations. We have a good example in how one man, an American specialist in fish migration, Arthur Hasler, used his experience of olfactory imprinting to gain insight into the biology of salmon homing. Three centuries ago Izaak Walton noted, in *The Compleat Angler,* that the practice of tagging salmon with a piece of string "has inclined many to think that every salmon usually returns to the same river in which it was bred." Yet how could a salmon swimming in the ocean ever find its way back to a tiny mountain stream bed?

Hasler argued correctly that salmon sniff their way home. Here is his account of how he came on the idea:

As I hiked along a mountain trail in the Wasatch Range of the Rocky Mountains, where I grew up, my reflections about the migratory behavior of salmon were soon interrupted by wonderful scents that I had not smelled since I was a boy. Climbing up towards the alpine zone on the eastern slope of Mount Timpanogos, I had approached a waterfall which was completely obstructed from view by a cliff; yet when a cool breeze bearing the fragrances of mosses and columbine swept around the rocky abutment, the details of this waterfall and its setting on the face of the mountain suddenly leaped into my mind's eye. In fact, so impressive was this odor that it suddenly evoked a flood of memories of boyhood chums and deeds long since vanished from conscious memory. The association was so strong that I immediately applied it to the problem of salmon homing. The connection caused me to formulate the hypothesis that each stream contains a particular bouquet of fragrances to which salmon become imprinted before immigrating to the ocean and which they subsequently use as a cue for identifying their natal tributary on their return from the sea.

Our sense of smell is still strong enough to haunt and beguile us. Who has not had some brief fragrance, the smell of a flower or summer rain, unleash memories and images of scenes and emotions long past which come surging back in detailed clarity. What memories may be filed under and conjured up so richly by, the scent of orange blossoms, while still other memories may await the scent of nutmeg or a thousand other redolences for their release. This link between smell and memory may now be mere atavism. But in the power of these associations we may gain an inkling of how it used to be.

Adrian Forsyth is a Canadian author who holds a Ph.D. in biology from Harvard University. He has been awarded the Canadian Periodicals Association's Gold Medal for science writing several times. He coauthored Tropical Nature: Life and Death in the Rain Forests of Central and South America, *published in 1984.*

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Very Volcanic Venus

The Venusian surface bears an uncanny resemblance to some hot spots on the earth's sea floor

by Stephen P. Maran

"I may venture to say that no eye which is not considerably better than mine, or assisted by much better instruments, will ever get a sight of them." So wrote astronomer William Herschel in the late eighteenth century, denying claims that mountaintops had been glimpsed poking through the permanent clouds of Venus.

Today we know that Venus indeed has lofty mountains, although none as tall (twenty-seven miles) as the one that the German observer J. H. Schroeter, Herschel's contemporary, claimed he had seen. Herschel's words, however, still ring true. The mountains of Venus surely have never been seen because their summits are located far below the uppermost cloud deck of the planet. Instead, the presence of the mountains is inferred from radar scans. Radar waves penetrate Venus's clouds and reveal the planet's features just as air traffic controllers use radar to search for aircraft through clouds in the earth's atmosphere. Large areas of Venus, including mountain plateaus, have been mapped with the huge dish-shaped radar telescopes at Arecibo, Puerto Rico, and Goldstone, California, and with small radar antennas carried by satellites that were placed in orbit around Venus by NASA and the USSR.

For years before the advent of radar telescopes, astronomers speculated about the nature of the Venusian surface. Inspired in part by the musings of a Swedish chemist who won the Nobel Prize for other work, some astronomers favored the theory that Venus was a humid, swampy world, its surface resembling that of the earth in the Carboniferous era, about 300 million years ago. Certain writers embellished this concept by supposing that the swamps were teeming with life, like those of the prehistoric earth. Unlike the Swedish Nobel laureate, however, there were astronomers who thought that oceans and continents are distributed on Venus much as they are on Earth. Critics of the latter theory were divided for the most part into two diametrically opposed schools of thought. According to the first school, oceans may be present, but if so, they cover the entire surface of Venus so that there is no land and there are no mountains (at least, none that rise above the surface of the sea). This remarkable concept of a watery planet was proposed only a few decades ago by two noted astronomers at Harvard University. Disagreeing with the Harvard men, adherents of the second school maintained that Venus was covered neither with oceans nor with swamps. Instead, they maintained that the surface of Venus is a broiling desert, with not a drop of water to be found.

Radar astronomers began a generation of studies of Venus in 1963. The first crude observations showed that some areas on the planet reflect radar more effectively than others. Tracking the echoes from these areas, the observers were able to measure the rotation of Venus for the first time. In the mid-1960s, however, the nature of the Venusian surface remained so much of a mystery that a radar astronomer at the Massachusetts Institute of Technology could only report that the radar echoes received from Venus were due to reflections of the radar waves at "the solid or liquid surface of the planet."

As more and better observations were obtained, the radar astronomers determined that the areas on Venus that are distinguished by stronger echoes, notably a region called Beta, which is characterized by two large mountains, are highlands. Some Venusian mountains appear to have depressions near their summits like the calderas of terrestrial volcanoes, and it is widely supposed that these mountains are shield volcanoes like the large volcanoes in Hawaii.

In October 1975, the Soviet probes *Venera 9* and *Venera 10* landed in the vicinity of Beta and sent back the first photographs of the Venusian surface. Because some astronomers thought that the surface might be only very dimly lit due to the thick clouds, the lander probes carried floodlights and their cameras were directed downward at the rocks around their landing points. The horizon in the photographs, where visible at all, is probably less than a mile from the probes, and no mountains can be seen in the distance, although at least one of the probes, *Venera 9*, may have touched down on the slope of a volcano. In any case, the *Venera 9* and *10* photographs showed a barren, dry, rock-strewn landscape.

Measurements by instruments carried by the *Venera* and other probes that have reached ground level on Venus showed that the temperature of the Venusian surface is 800 degrees Fahrenheit and more in accord with measurements by Earth-based radiotelescopes that recorded microwave emission from the planet's hot surface and atmosphere. Thus, the photographs and temperature data confirmed that the Venusian surface is a hot desert.

A remarkable property of the planet's surface is its enormous atmospheric pressure, which corresponds to about ninety-five times the surface pressure at sea level on the earth. Although there are no oceans

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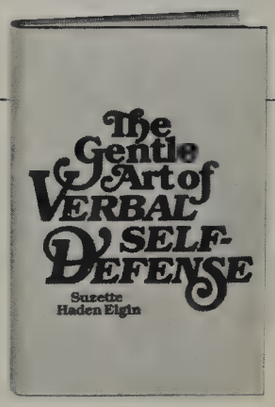
About the Author

Psycholinguist Suzette Haden Elgin has presented her innovative self-defense principles in a variety of formats. She has given workshops and seminars all over the U.S., including verbal self-defense sessions for doctors, lawyers, and other professionals. Dr. Elgin has also created a self-defense tape and a training manual for people who teach her self-defense techniques.



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on Venus, previous speculation to the contrary, the surface of the planet lies beneath a heavy and hot ocean of air, consisting largely of a dense gas of carbon dioxide.

That there seem to be volcanoes on Venus is not surprising, since there are many active and dead volcanoes on the earth. Furthermore, the American spacecraft *Mariner 9* photographed spectacular volcanoes on Mars, and the NASA probes *Voyager 1* and *2* actually caught volcanoes erupting on Io, a moon of Jupiter. *Mariner 9,* however, never observed an eruption or the immediate aftermath of one during a year of monitoring Mars. From this and geologic analysis of photographs and data from *Mariner* and other Mars probes, it seems likely that the Martian volcanoes are dead.

Lacking photographs of the Venusian volcanoes, it is hard for investigators to say whether they are currently active or not. Some experts, like Harold Masursky, a leading planetologist at the U.S. Geological Survey in Flagstaff, Arizona, contend that the topographic contours of the Venusian mountain regions, as inferred from radar, are suggestive of relative youth, a circumstance consistent with activity. Thus it was with extraordinary interest that I and other astronomers greeted a February 1984 announcement that recent volcanic activity on Venus had been deduced.

The 1984 announcement, by Larry W. Esposito, an atmospheric investigator at the University of Colorado in Boulder, was based on observations from satellites orbiting both Venus and the earth. Data from the Earth-orbiting satellite *Nimbus 7* had shown that the abundance of sulfur dioxide gas in our own atmosphere increased dramatically after the eruptions of the Mexican volcano El Chichón in March and April of 1982. Esposito discovered a significant trend in the concentration of sulfur dioxide at the cloudtops in the Venusian atmosphere. In 1978, when the *Pioneer Venus Orbiter (PVO)* reached Venus, it found sulfur dioxide to be present in substantial amounts near the cloudtops, although the gas had not been present to any significant degree when searched for several years earlier. Over the next six years, as *PVO* continued to circle Venus, its measurements revealed that the amount of sulfur dioxide at the cloudtops was steadily decreasing. From these data, Esposito proposed that a huge volcanic eruption, dwarfing even that of Krakatoa in 1883, had occurred on Venus shortly before *PVO*'s 1978 arrival. The sulfur dioxide, released into the atmosphere by the putative explosion, supposedly rose upward to the clouds, where

dually it was chemically converted to
psol particles of sulfuric acid. Accord-
to Esposito, as the sulfur dioxide
ned to sulfuric acid, the amount of the
measured by *PVO* steadily decreased.
Support for Esposito's claim that there
contemporary volcanic activity on Ve-
s came from Fred Scarf, an investigator
space physics at TRW, Inc., a major in-
strial corporation in Redondo Beach,
lifornia. An instrument operated by
arf, also carried on the *PVO*, detected
-frequency radio emissions resembling
se generated by lightning storms on the
th. Scarf found that the Venus emis-
ns occurred predominantly above two
untainous regions that radar astrono-
rs had classified as volcanic based on
ir shapes. Because lightning bolts often
ke the plumes above erupting volca-
es on the earth, Scarf suggested that the
ves observed by his instrument may
e been generated in volcanic plumes
Venus.

Both the Esposito and Scarf claims
e been disputed by other planetary sci-
ists, who suggest that sulfur dioxide
ld be raised to the Venus cloudtops
here *PVO* can detect it) by means other
n volcanic eruptions and that the radio
issions detected do not necessarily
me from lightning over the mountains.

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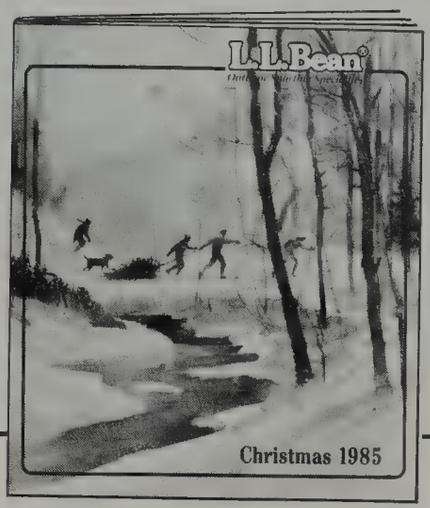

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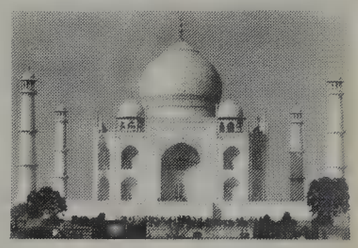

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According to one idea, sulfur dioxid present below the clouds could be raise by a process of convection, a massive a mospheric turnover. It would then de crease gradually at the cloudtops, throug transformation to sulfuric acid particles in the manner observed by *PVO*. Accord ing to some critics, the radio emissions as cribed to lightning storms above certai volcanoes might be produced instead b auroras high in the atmosphere of Venu or by lightning elsewhere on the planet Thus, the *PVO* observations, althoug suggestive of volcanic activity, are no conclusive. As for the direct observatio of a volcanic eruption on Venus, we hav yet to find the smoking gun, althoug *PVO* may have found the smoke.

The suggestion has also been made tha active or not, volcanism on Venus has a different style from volcanism on Earth Geologists use *style* in a technical sense In the context of volcanism, it refers not t what the well-dressed volcanologist wear in the field but rather to the manner i which volcanic activity is manifested. The earth, for example, has several volcanic styles, including the explosions of great cone-shaped stratovolcanoes such as Kra katoa and Mount Fuji, and the more gen tle, yet massive, repeated eruptions o molten lava that form huge shield volca noes, notably Mauna Loa in Hawaii. Stil another volcanic style is represented by the effusion of lava from submarine fis sures near the mid-ocean ridges. At those locations, called hydrothermal vents, the deep-sea water is heated and enriched with chemicals from the molten rock.

In 1979, Charles Wood, a geologist then at the Smithsonian Institution, pointed out that volcanic explosions had not been observed at great depths in the earth's oceans. Assuming that deep-sea explosions are deterred by the great pres sure of the overlying water, he suggested that explosive volcanism is equally un likely on the surface of Venus, where the atmospheric pressure is comparable to the water pressure at depths of a half mile or more on Earth. Since then, some evidence has been gathered suggesting that deep sea volcanic explosions may indeed occur. However, studies of Venus have concen trated on the likelihood that gentler lava flows like those of the Hawaiian shield vol canoes may predominate. Supporting this idea, radar maps of the Beta Regio region of Venus, which was proposed by Scarf as a source of lightning, are consistent with the identification of the area as a great complex of shield volcanoes.

Geologists at Brown University in Prov idence, Rhode Island, and at Goddard Space Flight Center, where I work, have

nsidered the possibility that the style of canism that occurs near hydrothermal nts and other areas of submarine volca- m on the earth also occurs on Venus. mes Garvin, a young Goddard col- gue and interpreter of Venusian rocks, cently told me he believes that the con- ions on Venus are very much like those terrestrial hydrothermal vents. The essures are similar, he said, and the sur- ge of Venus reaches temperatures of 0 degrees Fahrenheit and more, com- rable to, but even hotter than, those at e hottest vents beneath the earth's seas. rvin points to resemblances between ples on what look like solidified Venu- n lava flows, as photographed in March 82 by the Soviet lander craft *Venera 13*, d ripples on very young lavas photo- aphed from a submersible vehicle that plored the East Pacific Rise. Most strik- g to my eyes is the resemblance between at appears to be exfoliation (the peeling rock in thin layers along planes of weak- ss) in photographs made by the *Cyana*, French submersible craft, near the Mid- lantic Ridge and similar features found *Venera 14*'s landing point on Venus, o in March 1982. The observed Venu- n exfoliation may be due to changes in e temperature of the rocks, which cause em to contract or expand.

The surface of Venus, although not cov- ed by oceans as was once suggested, ay nevertheless resemble recently dis- vered regions of the Atlantic and Pa- ic ocean floors. Yet the Venusian sur- ce is far drier and hotter than any rrestrial desert. The explorations of both e earth's deep-sea floor and the surface Venus are still in their infancy. In many cations, our sea floor is dominated by the oducts of present and past volcanism. nus too is a very volcanic world, but nether the volcanism there is currently tive remains to be proved. Two future obes, the United States' *Venus Radar apper* and the Soviet Union's *Vesta*, are pected to reach Venus in 1988 and 91, respectively. Perhaps they will find e smoking gun.

ephen P. Maran is a senior staff scien- t in the Laboratory for Astronomy and olar Physics at NASA's Goddard Space ight Center in Greenbelt, Maryland. he opinions expressed here are his own.

RRATUM: In "A Taru Life Story," Sep- mber 1985, the caption on page 40 mis- entifies the species of hornbill pictured the top of the page. It is a red-billed rnbill (*Tockus erythrorhynchus*).

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Klipspringers, small African antelopes that weigh about thirty pounds, are too delicate to defend themselves against such predators as baboons and hyenas. But klipspringers are strong, nimble climbers and they are constantly alert.

Peter Johnson

Monogamy on the Rocks

For the klipspringer, an African dwarf antelope, fidelity is a life and death issue

by Robin Dunbar

From somewhere high above me on the cliff, a single shrill whistle breaks the stillness of the African dawn. I stop and scan the cliff carefully through binoculars, searching for the pair of zebra-striped ears that should be twitching nervously, pointed in my direction. Below those ears, almost indistinguishable in the jumble of rock and vegetation, will be the rest of a small fawn-colored antelope called a klipspringer.

The trick is to walk slowly enough along the cliff to attract the animal's attention but to make sure you don't frighten it into disappearing over the cliff's top. If you get it right, it will stand there stock-still, sounding intermittent alarm calls, while it considers the stranger on its territory. This gives you your chance to find its shape nestled in the camouflaging background. So long as you remain still, the animal will stay there, peering down at you over its pointed, cone-shaped muzzle, head to one side, ears probing for the slightest stir of danger. I've seen klipspringers stand like that for an hour, poker-faced, waiting to see who would be the first to move.

It was the Dutch settlers landing on the rocky shores of the Cape of Good Hope three centuries ago who gave these small antelopes their name. (In Afrikaans, *klipspringer* means "cliff hopper.") They have to be one of the best-named creatures in the animal kingdom, for they leap from rock to rock with delicate hops, pausing now and again to gaze quizzically over their shoulders at you. Among the smallest of the African antelopes, klipspringers weigh no more than thirty pounds and stand barely two feet high at the shoulder. They are stockily built, with powerful, thick limbs absolutely essential to an animal that lives on steep cliffs, where a talent for climbing can mean the difference between safety and ending up as a meal for some other animal.

I first came across klipspringers in the Simen Mountains of central Ethiopia a decade and a half ago. I was up at an altitude of 11,000 feet, and the local population was so dense that everywhere I moved I heard a choir of cautionary whistles. When you encounter an animal that often, you start to wonder about it, at first idly

Klipspringers pair off early and remain faithful to each other. Monogamy enables one animal to feed while the other acts as a lookout, but females need more food than males and thus do less guarding.

Anthony Bannister; Animals Animals

admiring its skill at negotiating sheer rock faces where a missed footing would send it spinning into oblivion, later puzzling over the details of its biology.

What struck me first was the remarkable strength of its pair bond. Field guides had always described the klipspringer as a solitary species, but I soon realized that wherever I saw one, I was sure to see another of the opposite sex. When I first encountered them, silhouetted on the skyline, only one animal was ever visible. But if I sat and watched patiently for fifteen minutes or so, the other would inevitably materialize from under a bush where it had been resting, just a few yards away. When I studied this I found that the average distance separating the pair is only about four yards. Indeed, the klipspringer is probably the most strictly monogamous of all mammals. Like many monogamous species, klipspringers live on a small territory, which they defend against intruders, using their sharp little horns to drive home the message of ownership when necessary. Such disputes occur about once every three days. In the relatively rich habitats of Ethiopia and Kenya, territories are only five to ten acres in area, but klipspringers living in the deserts of southern Africa often keep much larger territories.

One of the most conspicuous features of the pair bond is the way the animals take turns standing guard. While one guards, the other eats, and roles are alternated every fifteen minutes or so until each has eaten its fill. Then they rest (and sometimes doze) on some prominent boulder or cliff ledge that gives them a good view of the surroundings. This cycle is repeated every four hours day and night.

The significance of this was impressed on me when I carried out more detailed comparative studies in Kenya nearly a decade after I had seen my first klipspringer in Ethiopia. One of the sites I worked at in Kenya was Tsavo West National Park. Here, the animals lived on a large, boulder-strewn hill that was easily accessible to the many predators, such as leopards, hyenas, and even baboons, that stalked the dry savanna. The ground cover was very dense, consisting mainly of woody shrubs and tall grass, and an animal feeding there soon disappeared from view. In a predator-rich habitat like Tsavo, animals had almost no warning of approaching enemies. The klipspringers were particularly vigilant in this habitat. The "lookout" animal would stand on a high boulder above its feeding partner, intently watching the surrounding landscape for signs of danger. The division of labor seemed to be unusually strict at Tsavo, and the number of predators was the highest of the five sites in Ethiopia and Kenya where I studied the klipspringer. (In Ethiopia's Simen Mountains, on the other hand, predators were rare, and the mile-high escarpment provided a safe refuge. Here, the male and the female often fed together.)

I first realized the significance of this behavior when I watched one particular pair at Tsavo. The female of this pair was barely grown up and had taken up residence with the male only recently, after the death of his previous mate. As usual, the male took his turn standing guard while the female fed. When she was done feeding, she climbed up to stand beside him, nuzzling his muzzle with the signal often used to express a readiness to change roles. After a moment or two, the male descended and fed, while the female settled down to ruminate and keep watch. But a few minutes later, she became distracted and wandered off to feed in another area. The male, suddenly noticing that she was gone, bounded up onto the lookout point to take over once more. This happened repeatedly, and the poor male hardly managed to get a full meal for days at a time. Evidently, the male preferred to go hungry rather than leave the pair unguarded.

This incident underlines an important feature of the klipspringer relationship. It is not something that comes naturally. The animals have to work at it, and it takes time for a well-coordinated relationship to develop.

Most klipspringer pairs are formed when an immature animal joins one of the opposite sex that has recently lost its mate. In many couples, therefore, the animals are of different ages, though few mature before the age of two. At first the animals mesh very poorly in their newly formed pairs. But with time, things begin to improve as the newcomer makes the transition from being a juvenile with no responsibilities to being an adult that must defend its own territory and raise its own offspring.

Another example of the way in which the male and female coordinate their behavior is given by the ritual of scent-marking the territorial boundary. Once every

Anthony Bannister

A klipspringer, left, marks its territory by pressing the end of a twig into an open gland under its eye and wetting the twig with a secretion. When the secretion dries, below, it hardens into a smooth, black bead. The sight and smell of these signposts let other antelopes know that they are trespassing.

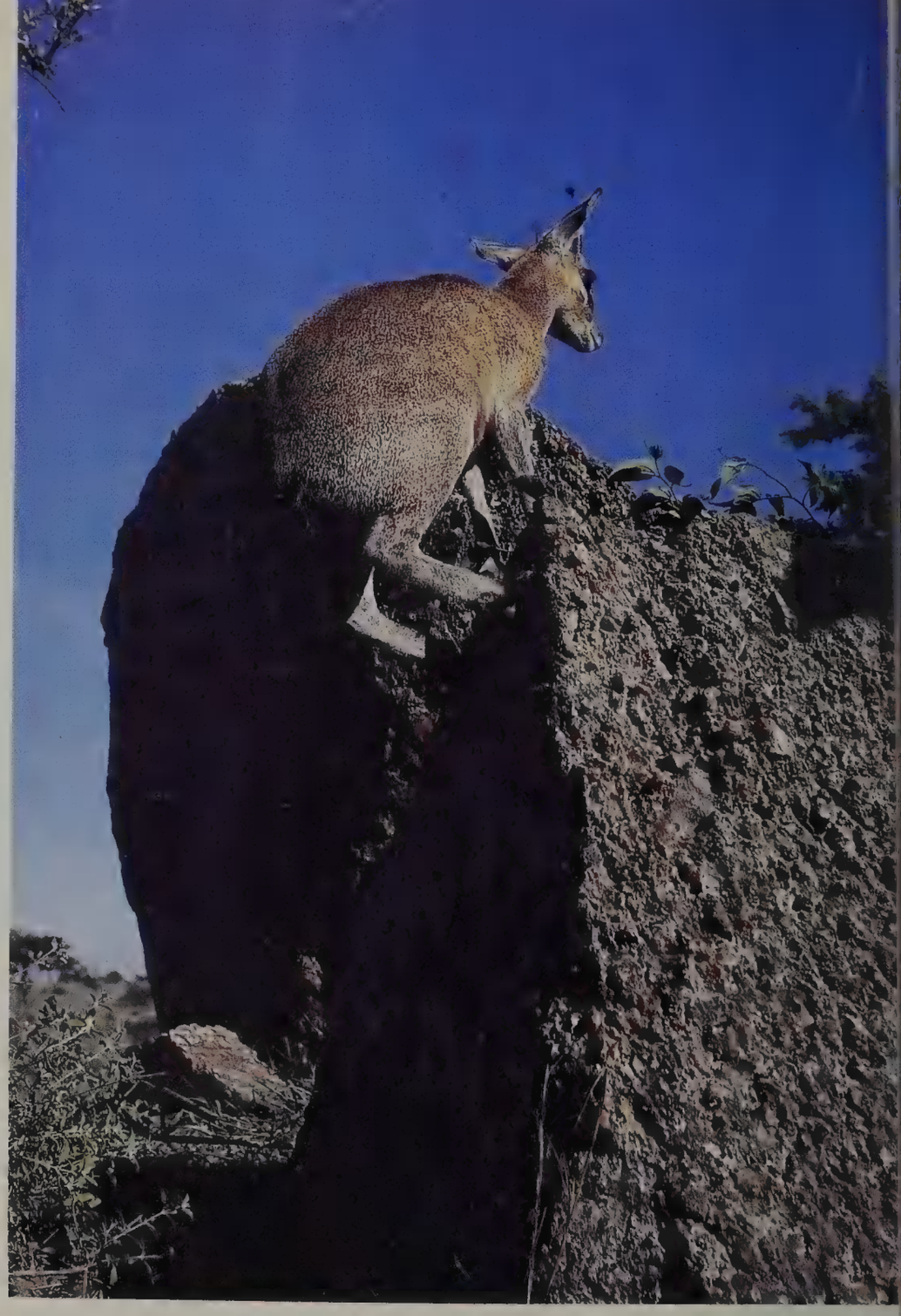
Anthony Bannister

ay or so, the pair will lay a trail of scent
arks along the edge of their territory.
sually, the female initiates the behavior
y walking suddenly toward the bound-
y. There, she marks the area by insert-
g the tips of twigs and grass stems into
n open gland just below each eye. This
aves a drop of oily, colorless liquid on the
ems that eventually dries into a glassy
lack coating. The male immediately
dds his marks on top of hers. The same
ems are used over and over again, and
ey acquire small, hard beads of secre-
on on their tips. To me, these marks have
o odor, but to klipspringers, they convey
good deal of information. They warn
eighbors and intruders alike that the ter-
tory is occupied and may even tell them
ho's there.

In most species of birds and mammals, monogamy is associated with male parental care. It tends to occur in those species in which the male's help is crucial to the survival of the young. For this reason, monogamy is common among birds but rare among mammals. It occurs in dogs and wolves, for example, because the male is able to help feed the pups by bringing meat back to the den. Some monkeys, such as the tiny South American marmoset, are also monogamous: in this case, the male helps the female by carrying the twin infants and caring for them in all ways except for suckling them. Antelopes, however, cannot carry their infants around in the way that primates do, nor do they eat the kinds of foods that can be easily brought back to a female and her young.

Another possible explanation for the evolution of monogamy in animals is that males in some species are forced into it because they cannot defend an area large enough to support several females. The klipspringer's preference for high-quality browse plants, such as flowering shrubs and herbs, may force the females to spread out, instead of forming groups as larger grazing antelope and deer do. However, the klipspringer's territory is not that big—a male could certainly defend an area large enough to cover the ranges of several females. Even if he couldn't, it still wouldn't explain why klipspringers have such an extraordinarily strong attachment to each other. The need to insure that the male be around once a year to mate with the female when she comes into estrus hardly seems to justify the immense effort required to maintain such proximity year-round. Something over and above these factors must be making it worth the male's while to invest so heavily in his mate.

Many hours spent peering through field glasses have convinced me that the answer lies in predation. So small an animal is inevitably susceptible to a wide range of enemies that includes many large eagles as well as terrestrial predators. It is particularly at risk on the flat ground at the base



of the cliffs. This is the best area for feeding, but the shrubs are so dense that the animal's field of view is greatly restricted. Ron Tilson, who studied klipspringers in the Namib Desert, found that almost all the attacks on adult animals took place while they were feeding on the flat land. My own data from Kenya tend to confirm this. In addition, a comparison of klipspringer death rates with those of dik-dik, another small antelope that lives exclusively on the flat ground in the same habitats as the klipspringer, showed that dik-dik suffer much higher predation rates.

Once I realized this, I started to see that virtually everything about klipspringers reflects predation as a selection pressure. Their whole preference for steep cliffs probably stems from a need to have both a refuge of almost unassailable safety from most terrestrial animals and an unparalleled vantage point from which to survey the landscape.

Predation even seems to account for one of the klipspringer's most extraordinary characteristics—its unique habit of walking on the tips of its hoofs. The klipspringer's hoof is turned under so the full weight of its step is taken on the conical tip. This gives the animal a characteristic, mincing sort of gait as it walks along. The value of this gait, I have learned, is that it creates ten times more friction on rough surfaces than walking on the flat of the hoof would. This enables the animal to move more quickly and with much greater sure-footedness up vertical cliffs that seem to offer no footholds. They are treacherous to walk along, and even four-footed animals are liable to slip. Klipspringers, however, get on much better than all others because their pointed hoof tips dig into the loose surface much the same way that a mountaineer's crampons dig into snow.

But what has monogamy got to do with predation? A buffalo or a zebra is big enough to defend itself and its offspring against most predators, but there is little an animal as puny as the klipspringer can do to defend itself or its mate. One thing it can do, however, is to act as its partner's eyes and ears. This allows its mate to get on with the time-consuming business of feeding without having to check constantly for predators stalking through the dense vegetation.

Does the male help the female by detecting predators more often than she does? Circumstantial evidence suggested that this was indeed so, but the hypothesis was difficult to test directly because I rarely saw predators get near the ever-alert klipspringer. What I needed was some way of knowing in advance when predators were coming.

My main study area, near Lake Elementeita in Kenya, provided me with an unexpected solution to this problem. A rough dirt road ran along the base of the mile-long cliff where the study population lived. During the course of the day, about a dozen people walked this road in ones and twos, on their way from their homesteads in the hills to a nearby market town. The klipspringer always reacted to these people as though they were predators. I was able to satisfy myself that this was so because now and again real predators, such as jackals, hyenas, and baboons, came down the track too. By defining people as randomly occurring pseudopredators, I could watch several hundred carefully controlled responses.

The road curved around the base of the cliffs at either end, so I was usually able to see people coming before the klipspringers did. I could then see which of the two animals detected the pseudopredator first and how soon it did so. I found that the male detected predators first much more often than the female did. In fact, the female sometimes saw the person only as he or she drew even with her position on the cliff.

Part of the reason for the male's acuity

Klipspringers live mainly on steep cliffs, left, from which they descend in order to feed. The animals are vegetarians and find more food on the flat ground, but that is also where predators find them.

Anthony Bannister

A couple of cliff hoppers feed on sparse shrubs. The conical tip of the animal's hoof is the key to its sure-footedness.

Anthony Bannister

was that he spent much more time than the female standing guard. Females had to spend about twice as much time feeding as males did because of the severe energetic costs of bearing young and producing the milk to nurture them. But there was more to it than just the time factor. When couples were resting side by side and facing in the same general direction, the male still picked out passers-by better than the female. In other words, the female seems to relax more, conserving her energies for reproduction.

So it seems one of the male's important contributions to the pair bond is that he is able to relieve the female of the need to be constantly on her guard. Doing so allows the male to sire more surviving offspring than if he deserted the female after mating and became polygynous. By helping to protect the female (the main caregiver), he will produce more descendants.

The male's level of vigilance is even greater when the young fawn is nursing. In Kenya, klipspringers give birth to a single fawn in March or April. Like many antelopes and deer, klipspringers leave their newborns hidden in the vegetation while the mother spends her time feeding. The fawns are not sufficiently mobile to move around with their parents until they are about three months old. In the meantime, they are easy prey for any passing predator. The fawn instinctively curls itself into a ball as soon as its mother leaves and remains motionless until the mother comes back to nurse it, often many hours later. As it is, about one in every eight fawns dies before reaching its first birthday, though not always because of predators.

I once stumbled by accident on a tiny fawn lying under a thick bush. I was moving cautiously through the scrub searching for scent marks and had stopped beside a bush to check the surroundings for signs of klipspringers. I must have been standing there for several minutes when I suddenly realized I was being watched. Not two feet from me, in the center of the bush, was a small fawn, no more than a week old. It lay absolutely still, eyeing me with an unblinking stare. At first, I thought it was dead because it did not seem to be breathing. But I hesitated to pick it up because antelopes often abandon their fawns if they have been disturbed too much. It was just as well. Looking closer, I could just make out the faint movement of the fawn's rib cage as it breathed. I edged away so as not to startle it into flight.

Once the infant is a little more mobile, it finds its own hiding place. At this stage,

A klipspringer pair check for predators in the area around a cliff. The antelopes sound an alarm whistle when they sense trouble, but they don't necessarily take off immediately. They may simply wait and watch, whistling intermittently.
Anthony Bannister

the mother does not seem to know exactly where her fawn is, only the general location where she saw it last. I suppose klipspringers do this because the fawn is less likely to be found by a predator if it keeps moving: odors that might attract a passing predator cannot build up so easily.

When the female is ready to suckle her fawn, she goes back to where she left it and begins to look around carefully, but she does not seem to be actively searching under bushes and rock overhangs. I suspect that she probably gives some kind of "milk" call to summon the fawn to her, but I never could get close enough to be sure of this. After several minutes, the fawn suddenly appears, runs across to its mother, and begins to nurse. It nurses for a surprisingly long time for such a small animal, some seven or eight minutes in all. This is probably because the female only comes to suckle it once or at most twice a day at this stage—possibly to reduce the risk of predation.

Throughout this exchange, the male stands tense and alert on a prominent rock nearby, scanning the surroundings with unusual intensity. A male klipspringer is normally quite relaxed while doing guard duty, but his whole demeanor changes during nursing. So intense is his concentration that, when I first saw it, I thought the male must have detected a predator and I kept looking around to see what it might be. I was so distracted that I never saw the fawn emerge from its hiding place and run across to its mother. It was only several minutes later that I suddenly became aware of the small brown creature butting away at the mother's side, and then, what I was witnessing finally dawned on me.

The klipspringer's is a story of single-minded dedication to solving a problem—how to avoid being caught by a predator when you are too small to do anything useful to defend yourself. It is an extraordinary example of a species' total commitment to solving that problem so that it can reproduce successfully. To be sure, every species has to avoid predators or reproduction becomes impossible. But few have done it with such unremitting devotion to duty as this little antelope. □

The Case of the Vanishing Caterpillar

A butterfly larva's fate depends on who finds it first—its ant friends or ant foes

Text and photographs by Gary N. Ross

Twenty-four years ago, I was a graduate student researching ecology in the Sierra de Tuxtla, an isolated volcanic range that rises from the Gulf coastal plain of Mexico, one hundred miles southeast of Veracruz. One remote habitat in the Sierra especially intrigued me because biologists had never noticed it. This was a small pine community found only on several of the steep ridges radiating down the southeastern slope of Volcán Santa Marta, a dormant, 5,250-foot-high volcano. There I discovered a new species of metalmark butterfly (lepidopterist Harry Clench of the Carnegie Museum honored me in 1962 by naming it Ross's metalmark, *Anatole rossi*).

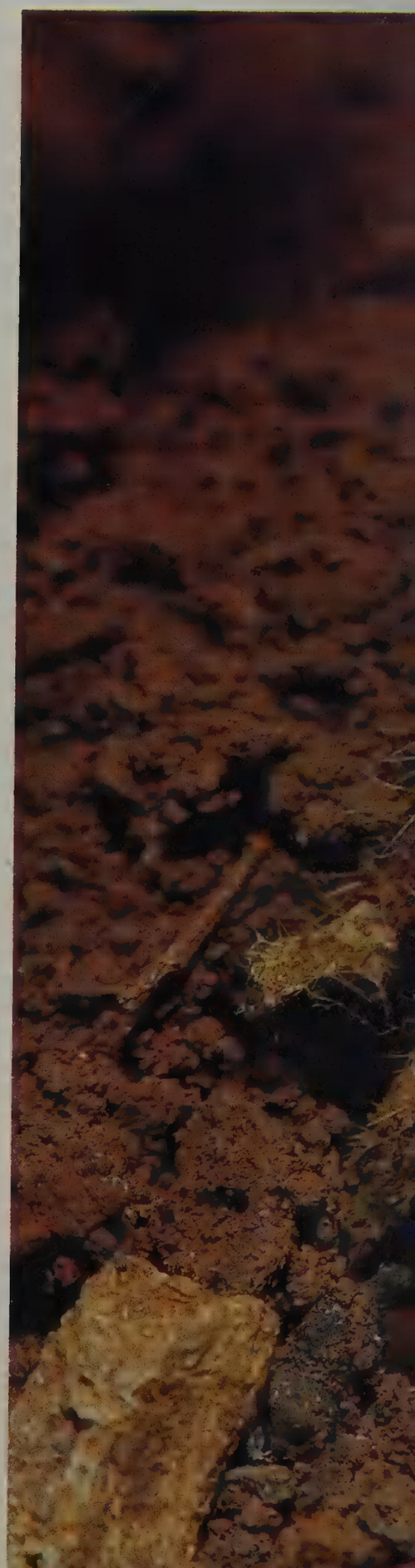
During the first month of my work in the tropics, when I began unraveling the metalmark's life history, some of the particulars came easily. I rapidly learned that the butterflies live in colonies and that females lay their eggs only on a particular species of croton, a ground-cover plant common in the region. I even discovered a few young larvae, or caterpillars. But then my luck ran out. Even though I found many severely damaged croton plants—they had apparently been eaten by mature caterpillars—I couldn't find a single large caterpillar or a chrysalis, the developmental stage in which the caterpillar metamorphoses into a butterfly. Where were the culprits?

Joe LeMonnier

I spent my days crawling about on hands and knees, often in rough terrain, searching for large caterpillars. Not finding any, I became very discouraged and resorted to hatching butterfly eggs and rearing the young larvae myself. My combination home and laboratory was a thatch-roofed, mud-floored hut, provided by my hosts, John and Royce Lind, American missionary-linguists who were studying the local Popoluca Indian culture.

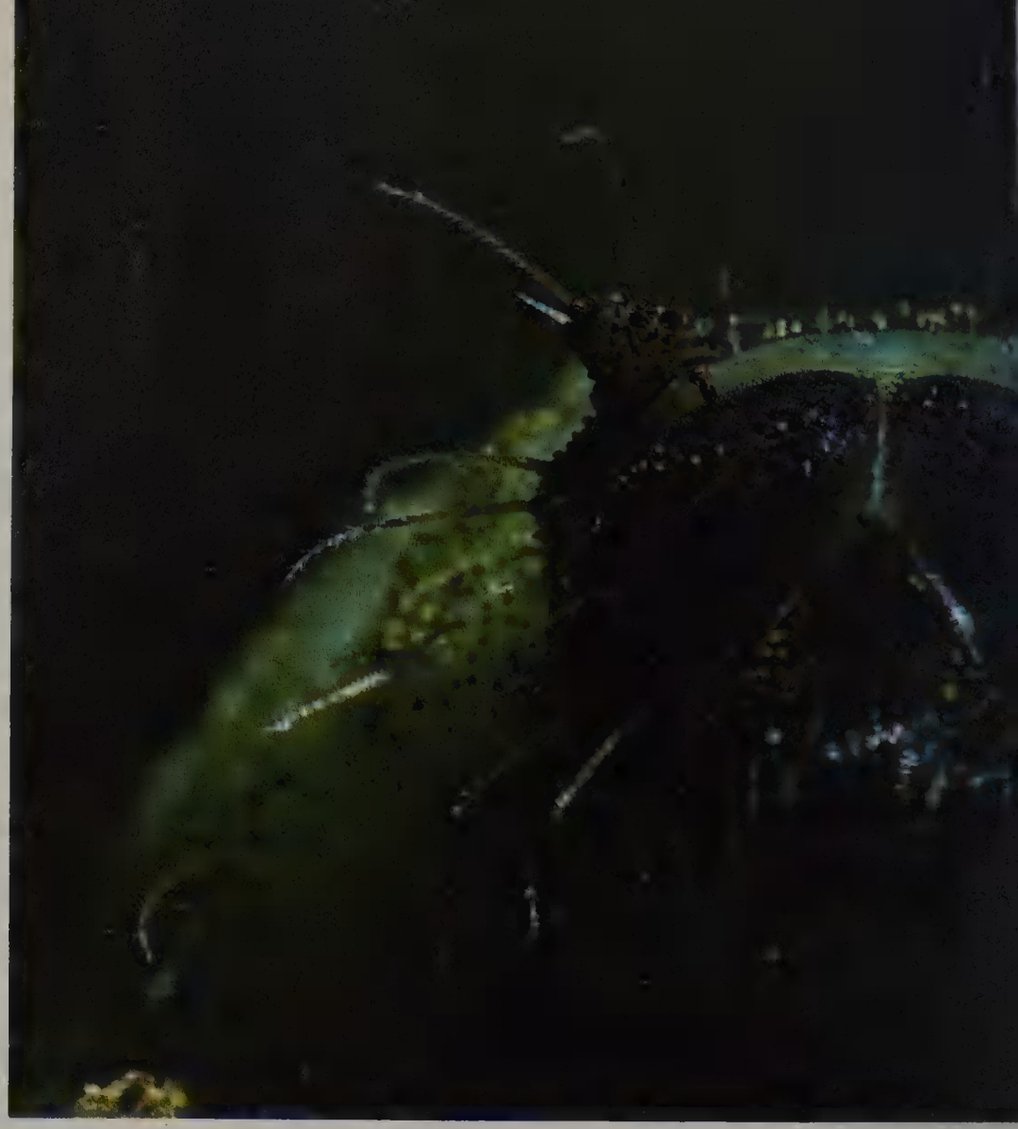
Reared in plastic sandwich-box nurseries, the young green larvae grew into large, plump caterpillars, shedding their skins six times in the process. After the second molt, each caterpillar began to secrete droplets of clear fluid from two openings on its back, near the hind end. Near its front end a pair of tentaclelike organs were periodically protruded and withdrawn. In addition, a pair of hard, bladelike structures, which constantly vibrated, projected over the caterpillar's head. At the time I hadn't a clue as to the functions of these organs, but my in-house experiments at least proved that the tiny larvae did grow into larger versions. Why couldn't I find any in the field?

One day, as I sat on a log in the midst of one of my metalmark colonies, nibbling a peanut butter and jelly sandwich (my lunch each day for several months) and pondering the mysterious absence of caterpillars, my reverie was disturbed by motion on a croton plant just three feet from where I sat. I dropped to the ground and drew closer. There, to my surprise, was a fully mature caterpillar, which I recognized from my "nursery" research.



Two Ross's metalmark caterpillars, accompanied by wood ants, emerge from the base of a croton plant.

Below: One of two honeydew-secreting glands projects from a caterpillar's hind end. An ant stroking the glands with its antennae will be rewarded with a sweet droplet.



Swarming over it were several large, reddish black ants. My protective instinct moved me to rescue the caterpillar from its predicament, but then I noticed that the ants were not attacking the caterpillar, which was feeding docilely; they were probing it, caressing it with their antennae. The caterpillar was protruding its tentacles in response, while the ants climbed aboard and drank droplets of the clear liquid that it released at its hind end.

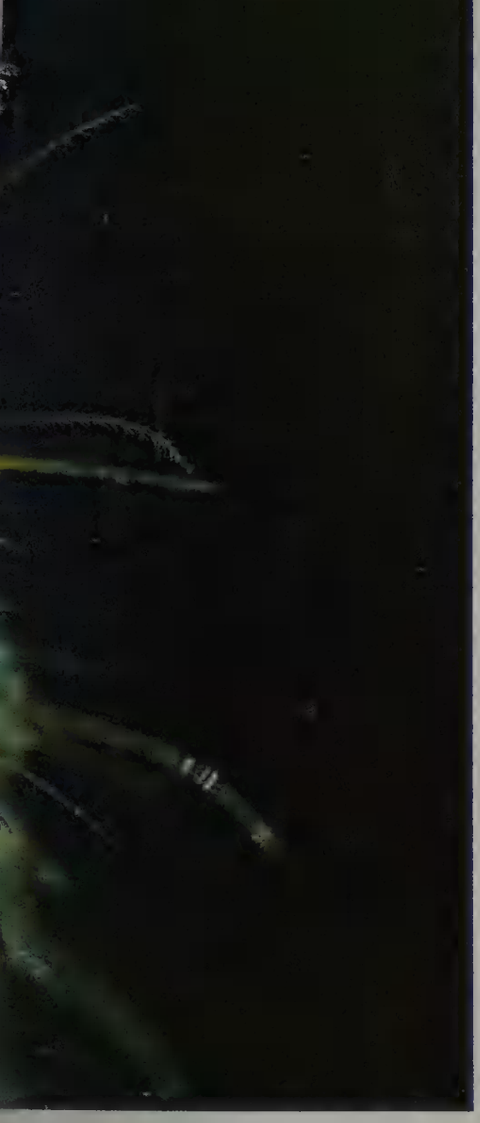
The caterpillar then began crawling down the plant, and within moments, it was in an underground chamber at the shrub's base—something I had never seen before. The ants followed, some hitching rides on the caterpillar's back. Once they were all inside the chamber, the ants closed it with dirt pellets, and all vestiges of insect infestation disappeared. My adrenalin soared! I quickly checked some partly defoliated crotons nearby. Adjacent to each plant was a subterranean niche containing from one to three caterpillars—large caterpillars—and ants; some of the chambers even contained chrysalises. Here was the solution to the mystery, and it had come about so unexpectedly. Although I've spent many years observing butterflies, caterpillars, and ants, I have never again seen these ants and caterpillars above ground during the day. They come out from their hiding places only at night. Had it not been for my chance encounter with what I like to think of as a gluttonous caterpillar sneaking in an extra meal, I probably would have given up the project of completing the metalmark butterfly's life history.

Following this revelation, I spent most of my hours—now at night, as well as during the day—on the pine ridges observing the caterpillars and their ant attendants. At night I used a flashlight covered with red cellophane, since my lantern, like any white light that the insects could interpret as dawn, disturbed the insects' activity. Even my camera's electronic flash had to be used sparingly and on intermittent nights in order to maintain nearly normal field conditions.

My nighttime excursions into the forest with camera, tripod, flashlight, and writing paraphernalia, sometimes during torrential thunderstorms, aroused the curiosity of the Popoluca villagers, whose large repertoire of folklore regarding "evils" of the night discourages nocturnal ventures. Within a short time I became the talk of the community, and speculation about my activities reached my American hosts. I learned that the most common theory about my wanderings was that I was searching for lost Spanish treasure, which the Popolucas believe to be buried in thei area. At first, this reaction elicited only a chuckle from me, but then the situatio became serious. One day I noticed tha someone had been digging in one of my colonies and had actually destroyed sev eral of my study plants and their under ground inhabitants. Since the Popolucas were unaware of the insects, they paid them no heed as they dug where I had been crouching and peering the previous night. They only wanted to see what treasure I had found.

Following this disaster, my hosts and I met with several of the village leaders. We assured them I was only a "nature lover," interested in simple things like ants and grubs on plants, and that if their digging continued, my project would be ruined and I would have to leave the area disappointed. Thereafter, I was not disturbed although I continued to elicit strange glances from many Popolucas, especially the village witch doctor, who continued to spy on me from the nearby shadows.

In the years since my discovery of Ross's metalmark, I have worked out its life history, which is probably the most complex of any known butterfly species. The butterfly is relatively small, with checkered brown, orange, white, and black markings. Like most other metal-



Protuberances over the caterpillar's head, left, shield two short sword-shaped beaters. These specialized appendages produce faint clicking sounds that attract wood ants. Below: An ant grasps a globule of honeydew in its jaws.

iarks around the world, the adults spend ıost of their time flitting rapidly two to ve feet above the ground or clinging to ıe tops and bottoms of leaves, where they ask in the sun with their wings outretched. In clear weather the butterflies re particularly visible late in the afteroon, when they dart about erratically and hase each other for short distances in the ıst rays of the setting sun.

The adult insects feed almost exclusively on the nectar from the white flowers f *Croton repens,* a wild relative of the ıore showy crotons raised indoors by ıany Americans and Europeans. The rst indication that the butterfly's life cyle is unusual is that, while the croton lants are widely distributed, the butterıes congregate in small, isolated colonies. hese colonies, which contain eight to fty butterflies, are found only on certain unny ridge crests and upper slopes and nly in the vicinity of the few human setements in the area—five small Popoluca ndian villages.

Within the butterfly colonies, the feıale insects lay their eggs on the undersurfaces of croton leaves. Hidden on the nderside of the leaves, the very young, inonspicuous green caterpillars spend their ays and nights nibbling the plants' tisues. Eight to ten days after hatching, a larva develops the specialized structures that I had noticed in my nursery. These enable it to attract its ant associates. A pair of glands near the larva's hind end produce a sugary secretion known as honeydew, which ants eat with the gusto of children devouring candy. A variety of insects—aphids, many scale insects, and to a lesser degree, certain butterfly and moth caterpillars—produce similar honeydew secretions. The tentaclelike organs near the front of the caterpillar secrete a gaseous chemical pheromone, or scent, which also attracts the ants. And the caterpillar's vibrating, bladelike structures produce faint clicking sounds, inaudible to humans but within the range of insect perception.

Not long after these specialized organs become active in a newly molted larva, the caterpillar attracts its associates, ants of the species *Camponotus abdominalis*, commonly referred to as wood ants or carpenter ants because they nest in old logs, fence posts, and even house beams. This species can be found throughout most of tropical Mexico and Central America. At night these ants scour the countryside (and villagers' kitchens) looking for, above all else, sweet things to eat. Needless to say, the *Anatole* caterpillars with their honeydew glands fill the bill.

When it first encounters a caterpillar during a nocturnal foray, the ant uses its antennae to stroke the caterpillar in the vicinity of the honeydew glands. The caterpillar responds by secreting tiny drops of moisture, which the ant imbibes. Usually within a few minutes, the ant worker is joined by several others of its kind, all of which consume the seemingly endless supply of treats. The wood ants do the caterpillar no harm, and after some thirty minutes of feasting, depart in relays to dig a small, shallow trench around the base of the croton. This excavation takes several hours but usually is complete by dawn. The resultant circular excavation is one to two inches deep. The ants then swarm about the caterpillar, constantly stroking it with their antennae. The caterpillar is induced to crawl down and soon finds itself underground. The ants quickly seal the entrance to the hole with small pellets of dirt from their previous digging. In a sense, the ant ranchers have herded their "cow" into its pen and closed the gate so that the milking becomes a private affair.

At dusk, between 7:00 and 7:10, the pellets of dirt are removed from the roof of the pen and the ants emerge, temporarily leaving their captive behind. They run back and forth over the leaves of the plant in a manner that suggests a search for potential enemies. To test if this was the

Below: In a subterranean chamber, a caterpillar attaches itself to a croton stem, sheds its skin, and becomes a chrysalis, or pupa. Although it produces no honeydew, the chrysalis will be tended by the ants for nine days of the eleven-day pupa stage.

case, on several occasions I placed small predatory arthropods, such as bugs and spiders, on the plants. The ants immediately seized these victims with their powerful mandibles, sprayed them from their abdomens with formic acid—an acrid liquid that smells something like vinegar—and carried them down the plant, depositing the virtually lifeless forms on the ground a few inches away. (Incidentally, the Popolucan name for these ants means "the sour-smelling ones." The villagers' language is rich with descriptive names for most common plants and animals; however, it doesn't contain a name for the elusive metalmark caterpillar.)

After about ten minutes of running over the plant, the ants return to the subterranean enclosure and vigorously stroke the caterpillar with their antennae, apparently coaxing it to move. The caterpillar now ascends the stem, shepherded by its carpenter ants, and eventually settles on a tender leaf near the top of the plant to begin feeding.

The feeding continues intermittently throughout the night, with the ants constantly in attendance, crawling over the caterpillar, pausing occasionally to imbibe droplets of honeydew, and running up and down the croton plant in search of marauders. The caterpillar, meanwhile, frequently emits its pheromone and vibrates its bladelike beaters, causing the ants to become more active and attentive. Between 4:30 and 4:45, just before dawn, the ants herd their charge downward and into the underground chamber. The roof is replaced, and even before the first streaks of light cross the tropical sky, both cow and herders are secure within their corral until the next twilight.

The daily cycle is rarely altered or interrupted during the summer and fall months. Even torrential rains do not have any observable deterrent effect. The underground pens are always located on sloping terrain of heavy red clay that provides excellent drainage, so the pens are rarely flooded. Besides, the insects are on the croton plants during the night, when most of the rains occur.

The caterpillars require nearly two months to complete their development. Then, like all butterfly and moth larvae, they enter a resting and transformational stage called the pupa. Unlike moth larvae, butterfly caterpillars do not encase themselves in cocoons. Instead, they attach their abdomens to stationary objects and shed their skins to reveal a new form, the chrysalis. Then, one of the greatest marvels of the insect world occurs: the lowly crawler is transformed into a winged gem of the skies.

The metamorphosis of Ross's metalmark takes eleven days. The process begins with the *Anatole* chrysalis in its chamber, attached to the subterranean portion of the croton stem or to its root. Although the organism does not produce honeydew in this stage, it does possess glandular openings corresponding in position to the pheromone-producing organs

ansformed, the pupa becomes butterfly, left. A newly emerged oss's metalmark butterfly, low, dries its wings.

the caterpillar, and I conclude that a nilar chemical is released into the air. any rate, the ants remain in the pen for ne days—until two days before the butfly's emergence. Then, as the adult rm nears perfection, its pheromone nds atrophy. The ants depart, leaving e pen open. The butterfly later emerges m the old pupal skin, climbs out of the rkness it has inhabited during the dayht hours for nearly two months, and ens the bright, sunny world of the pine ges. After an hour or so of drying and ercising its newly formed wings, the tterfly departs for a free, aerial exisnce, which it enjoys for as long as a nth, apparently oblivious to its past ant ociates.

Many questions arose in the course of observations. Do the ants remain with eir charge throughout its development do they sometimes return to their own st site? What would happen if the caterlars were isolated from their ants? Is the ociation between ants and caterpillars benefit to both species?

I experimented. First, I carefully ened a pen, and taking out the ants one one, I dabbed each on its back with a op of quick-drying paint. I repeated this ocedure with four nearby pens, using a ferent color for each. Three days later I observed that all of the painted ants had either been replaced by unpainted ones or else had moved to different chambers. There evidently was a changing of the guard as the ants circulated to and from their central nest and over their territory. Eventually I learned that the ants' nest may be up to fifty feet away, its inhabitants exploiting a variety of resources—saps, flower nectars, and other sweets. The caterpillars seem to be just one source of food they encounter. The ants' response—secreting the unwieldy prize in a hole instead of attempting to carry it back to the nest—may not have been specifically evolved to cope with the *Anatole* caterpillar. Similar behavior has been observed in several species of ants. The herding behavior may be a more specialized feature of the ants that evolved in association with these caterpillars.

In another experiment I removed the attending ants from several crotons and placed net cages around the plants to keep them out. When thus isolated from their caretakers, the caterpillars did not return to their subterranean cells after feeding but, instead, remained on the leaves and fed intermittently throughout the day and night. Evidently the daily journeys up and down the plants were forced on the caterpillars by the ants.

Then I removed several caterpillars and placed them on croton plants that were outside the butterfly-caterpillar colonies. Left unattended, the caterpillars were invariably attacked by workers of *Ectatoma tuberculatum*, large reddish ants festooned with numerous hairs and spines. This species is a member of a widespread group of ants, the Ponerinae, known for their fierce stinging ability and voracious predatory habits. The Popoluca's name for this species translates as "the robbers," appropriate for sinister-looking creatures that are frequently seen carrying assorted insect prey to their tree-hole nests.

I was personally well acquainted with *Ectatoma*. Just a few days prior to my relocation experiments, I had been stung on the thumb as I leaned against an oak tree. My finger was numb for nearly twenty-four hours and swollen for another day. I could imagine the damage such a sting would inflict on a caterpillar. I have since learned that, when stung, a larva undergoes extensive tissue destruction within a few minutes.

The relationship between the carpenter ants and the metalmark caterpillars thus appeared to be one in which the larvae furnished the ants with tasty sweets and in return received protection from a vicious armed predator, another ant species. To confirm this, I carefully investigated the pine ridge crests and upper slopes, exclusive habitats of the metalmark butterfly. The *Ectatoma* ants infested these open areas and spent the daylight hours solitarily stalking potential prey. At night, however, they remained secluded in their nests. The *Anatole* caterpillars and their wood ant guardians were prime targets, but they were hidden beneath the ground during the day when the predators were on patrol. At night, with the plundering halted as the *Ectatoma* ants stayed in their own nests, the caterpillars could feed in complete safety, exposed on their plants. Therefore, the relationship between the carpenter ants and metalmark caterpillars is mutually beneficial. Biologists call such a symbiotic relationship, in which both parties benefit, *mutualism*.

There is one other chapter to this story. During the cooler months of winter and

early spring, the ant–caterpillar activities are somewhat altered. Between November and April, nighttime temperatures may drop to 50°. Adult butterflies are no longer on the wing, having died as the cool, damp weather set in. The ants deepen the pens into five- to six-inch vertical tunnels, probably to increase insulation from the cold air. The butterfly's larval stage is greatly lengthened as the caterpillars and their attending ants become sluggish. Frequently a caterpillar will crawl up a plant during the early night hours, take a few bites, and then be herded immediately back into the pen. At times, particularly during very cool spells, the caterpillars do not emerge at all for many consecutive nights, presumably able to subsist on stored nutrients because of a reduced metabolism.

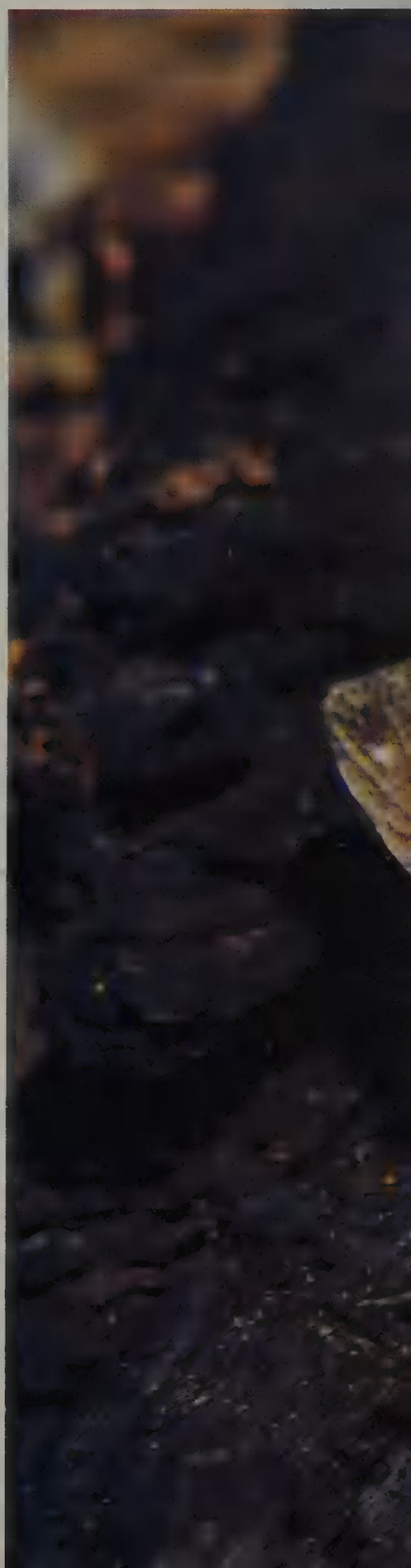
As spring, with its warmer temperatures, begins in the Sierra de Tuxtla, so does the dry season. Much of the undergrowth in the various ecological communities rapidly withers and dries. At this time, humans become an important factor in the perpetuation of the metalmark's life cycle. The Popoluca men toss lighted matches alongside the numerous trails on the pine ridges adjacent to their villages. The pine needles and dried undergrowth make excellent tinder, and the flames spread rapidly along and down the ridges. Because the ground is only sparsely covered, there is no widespread inferno, only low ground fires that creep in irregular patterns. The goal of this annual activity is to clear clutter from the ground in order to encourage the growth of fresh grasses that will serve as fodder for mules, burros, and horses. This allows the work animals to be pastured only short distances from the Popoluca villages.

By mid- or late April, selected sections of the pine ridges—and practically all butterfly-caterpillar colonies—have been burned over. However, because the wood ants previously deepened the pens during the cool months, the fires do not harm the secluded insects. They emerge the night after the firing and find a new world, one devoid of food plants and littered with burned debris. The absence of food for these winter-season caterpillars now triggers the onset of their long-delayed pupal period. No more than twelve days after fire passes through a colony, all the caterpillars transform into chrysalises. In two more weeks—by late April or early May—a fresh generation of butterflies is flying about.

Soon mating occurs and the females begin to lay their eggs. They select only the small shoots of croton plants that have recently sprouted from the bare, scorched patches of ground near their original larval food plants. The newly emerged crotons look much healthier than others growing in unburned localities. They are shorter, brighter green, and have relatively smooth leaves. The butterflies instinctively avoid placing their eggs on larger, more spindly plants with hairy leaves. While rearing caterpillars in my field laboratory, I observed that the young larvae could not penetrate the velvety surface of these larger plants; they soon became emaciated and died, presumably from starvation.

The distinctive growth form of the crotons in the metalmark colonies may be a response to the increased sunlight that pours into the burned-over areas. In unburned, grassy areas, even new-grown crotons produce hairier leaves. This difference, so important to the young caterpillars, remains in effect throughout the year. Thus, both the spring burning carried out by the villagers and the selectivity of the egg-laying butterflies insure colony stability and are critical to the survival of the species.

With the successful reproduction of the "spring crop" of butterflies, the cycle closes. Ross's metalmark seems to reproduce exclusively in an environment that is hostile to most other defenseless insects. It lives and breeds in a tiny habitat—pine ridges close to Popoluca Indian villages—that is burned regularly and systematically by the indigenous population and is the hunting territory of a potentially devastating ant predator. The butterfly thrives, where others cannot, because of its pact with a specific wood ant—a pact that, if somehow broken, would almost surely spell the butterfly's immediate extinction. □



The cycle is renewed as two metalmarks mate. The female will lay the eggs on the underside of a croton leaf. If the resultant caterpillars are not found and hidden by wood ants, they are frequently destroyed by stinging ants and other predatory insects.

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You'll also be very comfortable. There is more headroom even though the roofli is lower. The car is also wider.

You'll also see through a lot more gla because the windows are larger. They al fit flush to the doors and body so there's less wind noise. The body itself is rigid and solid. The car is stable.

© 1985 American Honda Motor Co., Inc.

ns haven't de yet.

Conveniences have been well sidered. This luxurious car comes with conditioning. A new electronic stereo tem with a cassette player. There are ver windows and door locks. A power o antenna. Dual power remote mirrors.

You might call the engine more of a verhouse. Its size has been increased wo liters. And its mounts have been redesigned to absorb vibrations. It's smooth.

Variable-assist power steering takes the rough work out of parking. Cruise control makes long trips even more relaxing. And the trunk is substantially larger so you can carry more luggage.

While these extras might be available as optional equipment on other cars, they come standard on this car. We invite your comparison.

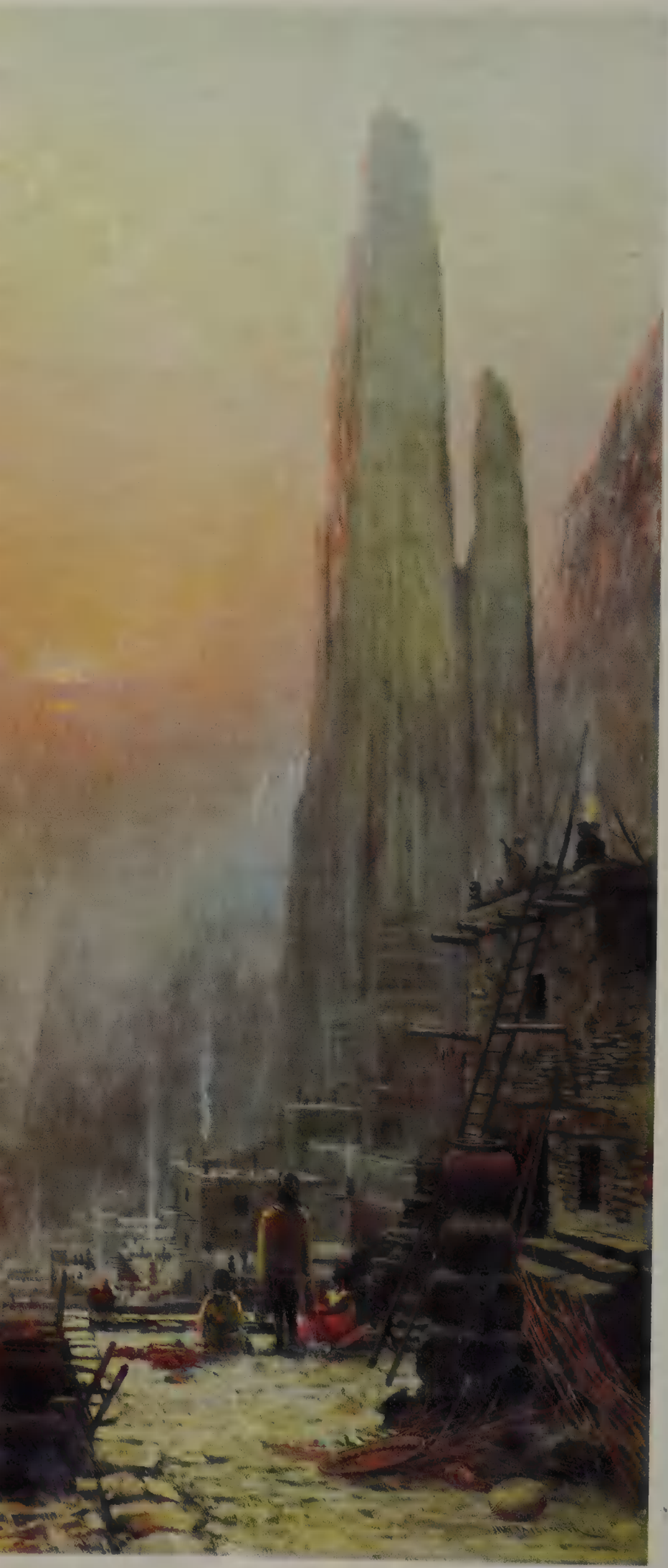
HONDA

The New Accord

Visions of a Big Sky

by Daedara Cunningham

Wind River, Wyoming (1870)
Albert Bierstadt drew field sketches while traveling with Gen. Frederick Lander's 1859 expedition to survey the cross-country wagon route later known as the Oregon Trail. From these sketches, he created many of his paintings, rearranging scenery and introducing additional elements for pictorial effect.



The vast area of land loosely termed the West stretches from the Mississippi River west to the Pacific Coast, across the Great Plains and past the Rocky Mountains to the coastline of Washington, Oregon, and California. Still, the seemingly endless prairies and high, soaring mountains bow to a yet greater expanse—the big sky.

From the time of the first westward expeditions, painters have been portraying these awe-inspiring vistas. In the mid-nineteenth century, explorer-artists used a flat horizon line that broke across the painting below the center. This device, more commonly used by marine painters, allowed such artists as William Tylee Ranney, George Inness, and William Jacob Hays to emphasize the vastness of space and the clarity of the sky in the Great Plains. Attempting to re-create the emotional impact that such spaciousness had on him, Inness also used shadows and grayish colors to evoke the mystical quality of the western landscape.

In the 1870s and 1880s, monumental landscapes, such as those by Albert Bierstadt, Thomas Moran, and Jules Tavernier, stressed human isolation in a natural setting of immense scale. Dramatic skies, mountains of exaggerated height, and diminutive human figures were the characteristic features of these works. Bierstadt felt he needed a huge canvas—often as large as six feet by ten—to interpret the true proportions of the western wilderness. Moran, who first traveled west with the Hayden scientific expedition in 1871 to explore the Yellowstone region, produced spectacular watercolors that played an important role in persuading Congress to set aside the area as a national park. Tavernier's paintings, with their luminous col-

Indian Village of Acoma *(1879)*
In 1873 Harper's Weekly *commissioned Jules Tavernier to tell the story of the West by making a pictorial record of those regions "where the railroads have not yet penetrated, where . . . even the squatter, the pioneer of civilization, has not yet erected his rude log-cabin."*

Children of the Mountain *(1886)*
Thomas Moran's watercolors of the Yellowstone region prompted the Hayden survey expediton of 1871 to name a 12,000-foot peak in the Grand Tetons in his honor.

Desert Southwest *(1944)*
In 1917, Louis Hill, owner of the Great Northern Railroad, commissioned Maynard Dixon to execute paintings of the Blackfoot Indians and Glacier National Park. Later, Cubist realism, as in Desert Southwest, *became the trademark of Dixon's landscapes.*

Red Hills, Grey Sky *(1935)*
A 1929 visit to New Mexico inspired the first of numerous semiabstract paintings by Wisconsin-born Georgia O'Keeffe.

ors, huge landmasses, and images of cave-dwelling Indians, reflect the late nineteenth century's preoccupation with the exotic nature of the West.

In the early twentieth century, illustrators-turned-artists, typified by William Herbert Dunton—best known for his illustrations of Zane Grey's books—recorded the rigors of the great outdoors in depictions of cowboys wrestling with animals and struggling against the elements. This tradition of recording—and romanticizing—human exploits in the West dates at least from the time of Ranney, who was greatly influenced by popular accounts of the feats of Daniel Boone and Davy Crockett.

Modernism and abstraction have also touched the art of the West, particularly in the last fifty years. The work of Maynard Dixon reflects this direction in his use of vivid color and simplified geometric

Browning, Montana, Bicentennial Indian Encampment *(1976)*
Wolfgang Pogzeba's fascination with the Indian powwow encampment led him to travel across Wyoming, Montana, and western Canada in 1976 to photograph and paint this vanishing tradition of the American West.

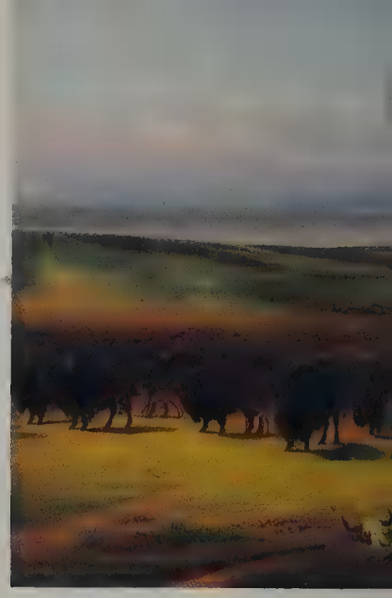
The First Iron Horse *(1901)*
Frank Sauerwein captures a moment of transition in the settlement of the West, as a group of Indians encounter the railroad. He is best known for his sketches and paintings of the Indians of Colorado and New Mexico.

form. Known for his portrayal of Indians (he lived among various tribes) and for his landscapes, Dixon was an illustrator for popular eastern magazines until 1912, when he returned to his native California determined to capture the realistic West he knew rather than the mythic West demanded by New York editors. Georgia O'Keeffe's personal vision of the West emerges in the recurring images of the empty sky and red hills of New Mexico, where, she says, "one seems to have more sky than earth in one's world." The sky is the overpowering feature of her paintings—a constant juxtaposed against hills, bones, and other elements of the landscape. The recent work of Chuck Forsman draws on two elements of modernism—realism and abstraction—to convey the expanse of the western landscape. Like Maynard Dixon before him, Forsman rebels against the romanticization of the West. A former ranch worker and park ranger, Forsman's declared artistic purpose is to depict the precariousness of the current ecological situation in the West.

While exploding urbanization and agricultural technology have brought many changes to the West, much remains unchanged: wanderers may still roam the plains and mountains undisturbed; the vastness continues to inspire awe. Above the sprawling land, as far as the eye can see, the big sky remains.

Elizabeth Cunningham is the curator and director of exhibitions for the Anschutz Collection, Denver, Colorado.

Masterpieces of the American West, a visual history of the frontier, will be at the American Museum of Natural History from November 29, 1985, through February 16, 1986. This selection of paintings from the Anschutz Collection in Denver will travel to Honolulu, Chicago, Birmingham, Little Rock, and six other cities before ending its tour in August 1988.



Dirt Rider *(1980)*
The title of Chuck Forsman's painting refers to the unseen motorcycle rider whose tracks have scarred this desert scene and, metaphorically, to each human who despoils the earth.

The Gathering of the Herds *(1866)*
In 1860 William Jacob Hays—who was born in New York City and spent his life there—made an 1,800-mile steamboat trip up the Missouri River, a journey that had an enduring influence on his work. Today he is chiefly remembered for his many large canvases of the animals of the Great Plains.

Although the village of Santa María now has tractors, some farmers continue to use teams of yoked cows. The art of training cows to the yoke is being lost by the younger generation of villagers.

Past and Present in the Spanish Countryside

Land consolidation is dismantling community practices that have been in place since medieval times

Text and photographs by Ruth Behar

In the foothills of the Cantabrian Mountains of northern Spain lie hundreds of tiny villages. Most came into being during the eighth to tenth centuries, when the first Christian Spanish kings "reconquered" lands that were under Moorish rule. Early colonists settled in the largely deserted areas and took possession of the land they could clear and cultivate, while woods, meadows, and wastes became community property. Today in León, a province of the southern foothills, the larger, greener villages stretch alongside the narrow rivers that descend from the mountains; upslope from the river banks are smaller, arid hamlets, austerely golden and brown. The village of Santa María del Condado, neither wholly green nor wholly arid, lies above the river banks yet is amply watered by springs and a communal dam.

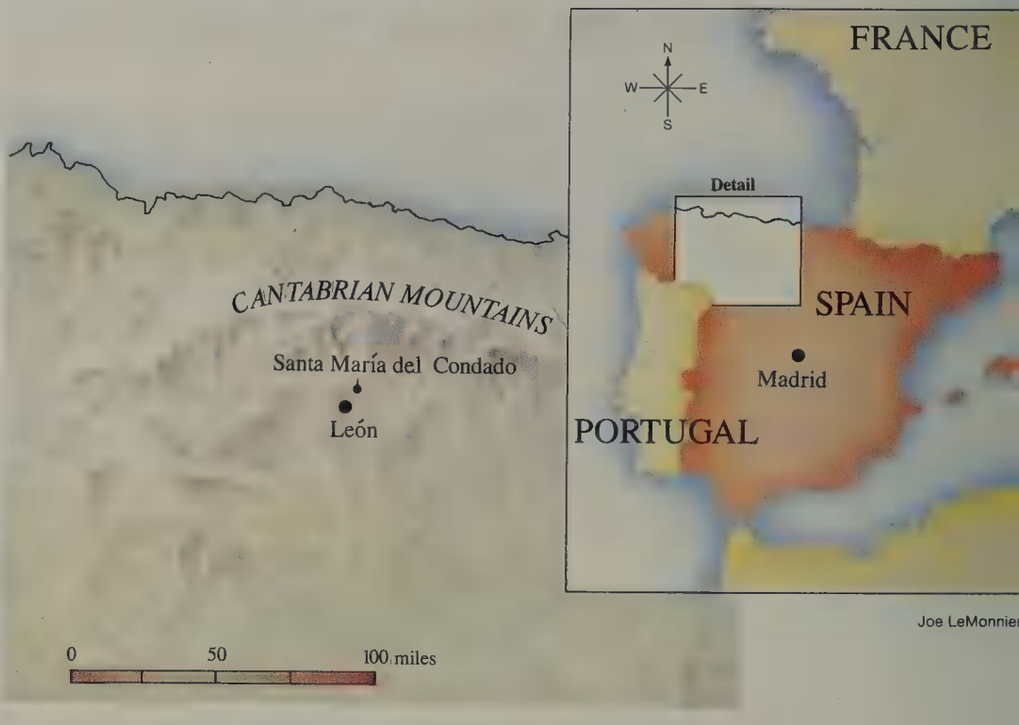
With 120 permanent residents, Santa María is distinguished by the common woods that surround the village (the community's historical name, still often used, is Santa María del Monte—Saint Mary of the Woods). The woods, which in the past secluded the village somewhat from neighboring communities, have long affected the tone of communal life. At the end of the nineteenth century, when the population more than doubled, the availability of spare woodland, which could be cleared for planting, cushioned the divisive effects of population expansion and kept village families from going hungry or sinking into the ranks of the rural proletariat. Santa María is well known in the area for having maintained a solid front during the Spanish Civil War despite political differences, unlike neighboring villages, in which some people denounced their enemies to the Civil Guards.

The ideal of unity, of *unión*, long important to villagers, was expressed in the reciprocity and cooperation of the traditional system of land tenure, which in Santa María survived until recently. During several visits to the village from 1978 to 1981, I saw farmers still following communal agricultural and pastoral practices that were once widespread throughout Spain and Europe. These included the yearly alternation of planting and fallowing the grain fields, which the entire community followed; the opening up of the harvested fields to all of the village's cattle for grazing; the imposition of community rights (what Roman law called "servitudes") on various private properties, making them subject to village use; taking turns for herding and irrigation; and finally, the allocation of common pasture and woodland to village families.

In England and elsewhere many of these practices disappeared in the eighteenth and nineteenth centuries as a result of the destruction of the commons, the enclosure movement—an early attempt to enforce land consolidation through special laws—and other measures that sought to rationalize the old agrarian system. The people of Santa María, though, like most other Leonese villagers, were barely touched by this agricultural revolution then sweeping western Europe. They continued to farm into this decade in ways that agrarian reformers had pronounced

This article is based on the epilogue to Ruth Behar's forthcoming book, *Santa María del Monte: The Presence of the Past in a Spanish Village*, to be published in the spring of 1986 by Princeton University Press.

Older people make up the majority of the villagers. Many young men and women left for León, Madrid, and Bilbao during the rural exodus of the 1960s and 1970s. Below: An older woman works in her kitchen garden.



Joe LeMonnier

irrational, barbaric, and outmoded two hundred years before.

Returning to Santa María in July of 1984, I passed through the landscape I had known so well, just thirteen miles away by highway from the city of León. I saw the familiar valleys and heather bushes, the yellow fields brimming with stalks of rye, the burnt red soil, the fallows overgrown with wildflowers and weeds, the strange wavelike patterns sewn into the hillsides by erosion, water, and time. Nearing the village, however, I began to notice the unfamiliar, to see things that tested the vision I held in my memory.

I was not surprised to find the layout of the land changed. I had corresponded with several people in the village, and their letters had charted the gradual, but imminent, progression toward land consolidation. During my previous stays in the village, the question of whether to accept the government-sponsored consolidation of the scattered parcels that made up each family's landholding had been discussed and battled over in numerous village council meetings. The program's aim is to transform the dozens of tiny fields belonging to a household into three or four larger, more regular plots, as well as to build roads to make the plots accessible by cow team or, increasingly now, by tractor. Even before my first visit, the village had requested this service, yet people acted as if the plan would never go into effect. Year after year I watched as people scrutinized the series of maps the engineers brought to the village meeting house at every stage of the process; there were so many dissatisfactions and complaints that I, too, began to believe the layout of the land would remain the same forever. But finally, in January 1984, the bulldozers finished the major roadwork, and the people were given computer printouts identifying the fields that the engineers had devised for them.

Information about the changes that were taking place had come to me in bits and pieces, but it was difficult for me to imagine exactly how the landscape had been altered. As I drew closer to Santa María, I could see, with the sort of intensity that only first impressions can call up, that the village was exposed, like a sheep just sheared of its wool. Before there had been more trees, more hedges, more gardens; now there were large fields of barley and oats reaching right up to the houses, practically touching them.

That things had changed radically, irrevocably, was not simply my own perception; it was also that of the farmers of Santa María. I remember explaining, in 1978, that I had come to Santa María to study the way of life of the village and being told, by the woman in whose house I lived that year, that theirs was a harsh life, for the work they had to do was "brutal, very brutal." A number of times I heard the phrase *la tierra es muy señorita*, "the land is a very spoiled girl"—in other words, the land will not do a thing for you, you have to work and slave "for her." On my return to Santa María, the remark I

rd most frequently, almost daily, was
t no one wants to work anymore, no one
ws *how* to work anymore.

August, as I remembered it, was the
e of greatest agricultural activity in the
r. All month long one would see people
urning from the fields with carts brim-
g with stalks of rye, the new Leonese
ed of cows—intended for milk—pull-
the load. A number of people could
y be seen in the fields or on the thresh-
grounds, and some families threshed
winnowed, with machines twenty and
ty years old, almost until midnight.
e threshing grounds would be crowded
h people, carts, cows, piles of hay and
in. A young man from the village, who
s a bar in Madrid with his brothers,
hed past me one day, saying, "This is
rse than New York City, what do you
nk, Ruth?" Theirs was hard, exhaust-
work, yet everyone was quick to point
that although they worked hard, their
ents and grandparents, not to mention
se who came before, had worked
der. In a past not too distant, the rye
s mowed with the sickle, threshed with
threshing sledge, winnowed with the
wind.

Finding the threshing grounds virtually deserted, I innocently asked people whether they had already brought in the rye harvest or if they were somehow starting late this year. I was told, by everyone, that they had not yet touched the rye, that they had contracted for combine harvesters to do the job. They would get there any day now, people kept saying, as the first week, then the second week of August passed by. People always spoke of the combines alone, not of the men with the combines, as if those imposing machines had a life of their own. It was strange to see people waiting for the harvest to be brought home for them; strange, as one man said, "that it should be August and not a soul in the fields or on the threshing grounds." When the combines arrived, just after the middle of the month, everyone breathed easier; until then there had been a great deal of anxiety in the air—what if hail had fallen or too much sun scorched the grain? So many things could have destroyed the harvest.

"In four days," Luis Puente told me, "they harvested what they used to harvest in two months." He was raised in the Basque country, where his family had moved in the 1960s. Although only twenty-two, he could remember coming back to Santa María when he was a child to help bring in his grandparents' harvest with sickle, scythe, and threshing sledge. The changes he has seen in his short lifetime, he said, amounted to a progression from "the Stone Age to modern times." In 1981 a few people had tentatively called upon the combine to harvest a field or two; before then no one had. Since then, everyone has used the combine for the rye harvest if not always for barley, oats, and wheat, which are grown in smaller quantities. "You can't work the way we used to any more," Leonardo Mirantes, a retired farmer, said to me as we stood around one Sunday talking. Sixto Mirantes, another retired farmer, added, "These days no one *wants* to work the way we used to!"

Until 1981 there were three tractors in the village; now there are seven, serving twenty-six working families. The tractor owners are the ones who, with their families, raise ten or twenty head of cattle each and work as much land as strength and time will allow. These families rent parcels from retired villagers or from those who have emigrated to the cities. Even the people who continue to work in a more traditional way, with a team of cows (oxen were given up in the 1930s), recognize that their way of life is dying and that Santa María's future as a farming village depends on increasing mechanization.

One morning, while walking through the deserted threshing grounds, I met two brothers from the village, each leading a pair of yoked cows. Both teams were made up of an older cow accustomed to the yoke and a calf wearing it for the first time. Froilán and Emiliano Mirantes led the cows around the threshing grounds for an hour or so; this, they told me, was to get the calves used to the yoke. I followed along, and we talked about how it would soon be impossible to find any beasts of burden in the village; Froilán remarked that when his neighbor, who works with a tractor, needs a team, he always borrows one from him. A certain patience is required to train a team, a certain sense of

David Fry

Before the consolidation of farmlands, everyone in Santa María had a little bit of every type of land—meadows, fields, and plots close to home for planting kitchen gardens, left. The shaded portions of the map at left show the scattered parcels of land worked by one family before consolidation. The map at right shows the holdings of the same family after the government-sponsored reforms. Below: Women sift garbanzos and sweep the threshing ground.

ıe and work and the bringing of things fruition.

For the older people, who are the major- in the village (many young people left León, Madrid, and Bilbao in search of nore comfortable, urban way of life dur- the rural exodus of the 1960s and 70s), the three, four, or five fields the gineers gave them just don't seem the me as the forty, fifty, and sixty plots that ey had accumulated through inheri- nce, destiny, and their own hard work. ıt they have accepted land consolidation th a mixture of resignation and defeat, a nse of its historical inevitability.

Once I went to observe the irrigation of me hillside lands close to the village m. I could still see the borders of the old nall plots engraved in the new landscape, if a map of the fields in the past had en placed on top of a map of the present. There I encountered Felicísimo Llamazares, a farmer in his seventies, who was beginning to irrigate with the runoff flowing down from the fields above his. He had carved out a miniature garden plot—lush with string beans on runners, onions, cabbages, and potatoes—in the middle of a large inert meadow. The upper part of the field, higher on the slope, was covered with weeds and dry grass. It could produce if it were plowed, he told me, but he wasn't going to bring in the plow. If his children wanted to, they could, but they probably wouldn't either. He said that he and his wife had already worked hard all winter cutting down trees and pulling out the old hedges to refashion their new plots.

I asked if he was pleased with the consolidation that had been carried out. He shrugged his shoulders and said that he thought that in the long run it was for the best. He had owned fifty plots, but his children no longer knew where most of them were; now, with five, they could keep track of their property more easily. Not that his children would ever work the land, he added, but who knows? And he cited a proverb: *Por los años mil, las aguas vuelvan a ir por donde solían ir* (Every thousand years the waters flow again where they once flowed). He explained that you can force water to go in a certain direction, but after a while, if left alone, it reverts to flowing the way it used to. "In other words," he said, "in twenty, thirty, one hundred years, maybe those people who left will return to where they used to be, which is the *pueblos*."

This is wishful thinking. Save for an economic disaster, those who left the villages are not going to return to cultivate the land. This realization is behind the village's approval of consolidation. The scattered plots of the past, which formed part of a web of persons, rights, and obligations, are not a meaningful inheritance to children who have moved to the cities.

With consolidation, the fields were made larger, the irrigation canals were widened, and bulldozers enlarged the old roads and plowed new ones where there had once been cultivated land. To accomplish all this, to make every field accessible by road and not just by footpath, many trees were cut down. The tree-lined lanes that led to the two communal meadows are now completely bare. When people received their new parcels, they cut down the trees and hedges within them, and many even removed the borders of foliage and knitted twigs and put up barbed-wire fences. A number of people spoke of how strange the village seems now, how foreign. New trees will be planted as time goes by, but for the moment it is the bareness that impresses.

The wastefulness of the new system as opposed to the old is often noted—how in

Rye, once harvested with sickles and scythes, below, is now harvested by machines. A combine, right, is loading the harvested grain onto a tractor wagon.

the past every ear of wheat, every stick of wood mattered, but how today thoroughness is sacrificed for speed. Those who are accustomed to working in the old style still approach the land with patience, giving it intensive attention every day without fail. But the large fields demand an extensive manner of working the land. As people point out, the very idea of plowing one of the new fields with a donkey or a pair of cows is exhausting. Nevertheless, villagers now recognize that modern farming calls for a dehumanized landscape.

A popular slogan about consolidation is "He who loses, wins" (*El que pierde, gana*). In other words, even if the fields the engineers gave you do not total up in acreage to what you had before, because all your property is now brought together, it is worth more to you—whether or not you work it yourself. For those who remain in the village and manage some, if not all, of their property, the large new parcels are more convenient. Those who are too old to farm or no longer live in the village lease their fields to the handful of tractor-owning families; now they can charge a proper rent for them because they no longer have *cachines*, little pieces everywhere, but *buenas parcelas*, good-sized parcels.

Consolidation has produced certain inequalities and irrationalities, however. As one man put it, "They say that those who lose win, but there are some who win 50,000 and some who win 500,000." The reference here is to the real estate value of the land. For example, just after the fields were consolidated, a woman who no longer lives in the village managed to sell a plot located on the edge of the settlement for 500,000 *pesetas*. Another woman, expecting to earn as much, tried to sell a plot located some distance from the settlement, but no one offered her more than 50,000 *pesetas*. The plot near the village could, and probably will, serve one day as the location of a summer house, since it can be easily linked into existing water and sewage lines. The plot at a distance, however, has value only as agricultural land, and such land is easy to come by.

When, with the help of a few villagers, the engineers rated all of the village lands, they took only the productive value of the land into account. The plots people have received with consolidation are no doubt as productive as the ones they had before, but their real estate value is another matter. In the last five years, a summer retreat has sprouted up across the highway from Santa María, on lands that were once part of the communal woods. And the young people who have moved to the city also desire a summer home, a *chalet*, in their natal village. This demand for land near the settlement has grown and will continue to grow. No wonder people use images from the lottery to talk about consolidation, speaking always of how so-and-so "wo or "lucked into" choice property.

Other inequities have come about sinc consolidation. One of the rationales b hind the old agrarian regime was that e eryone ought to have land of every type– at least a meadow, a garden plot, a field grow rye, a field to grow chickpeas, mayb even a field for wheat or oats. The plo were scattered, partly through destiny an inheritance (which, in León, has alway been equal between male and female sib lings) but also because people believe that it was better not to have all of the ha vest in one small area, where a burst hail or a sudden frost could destroy it.

The engineers who drew up the plan for consolidation fashioned nice, squar fields out of the long thin strips and jagge plots that had existed before. The notio that everyone should have a little bit land of every type made no sense to the en gineers; instead, they gave people thei new fields where they had previously ha the greatest concentration of plots. Whe I was at the threshing grounds one da

th two sisters, Inés and Amparo Rodríez, who were sifting chickpeas with a eve, Inés remarked on the small yield. ad it not been a good harvest? I asked. o, it wasn't that, she told me; it was just at, with consolidation, they had gotten any sandy fields that were good for ain, but hardly any of the thick clayey nd that is ideal for chickpeas. Before, e said, you had a bit of every kind of nd. Today there are people who don't en have a little land close to home to ant "four onions," in other words, to rm a kitchen garden.

Now that every field has access to a ad, there is no longer any need or excuse cross a neighbor's field to reach one's vn. In the past there were always probms with teams and carts causing damge to a neighbor's crops. Yet there was a nse that no one, no matter what degree self-importance he or she possessed, uld remain aloof from his or her neighrs. The layout of the land prevented it. onsolidation represents the very opposite such a conception; it frees the landholder of all servitudes, all ties to the community.

But no change in land tenure can do away at one stroke with the patterns, conceptions, and ideals of the past. Attitudes toward time, work, and the land are changing in Santa María, but these new attitudes have not replaced the old ones; instead, they now coexist, sometimes in strange juxtaposition, with peasant attitudes that have been passed on for generations. Some couples still thresh chickpeas with the threshing sledge, the women winnowing and sifting the crop with the sieve. Many families still bring the harvest home in their cow carts, and some farmers, long past retirement age, milk their five or six cows by hand every morning and evening. Men still train cows for the yoke, while miniature jewels of gardens are set in fields too large for those accustomed to close contact with the earth.

The common lands have not disappeared. Shares of the communal rye fields are given out every ten years to those families that can work them, and shares of the communal woodlands are distributed every fall so no one will lack fuel for the woodstoves that warm the houses during the cold winter months. In the summertime, most families still pasture their cows on the communal grazing lands, and participating villagers take turns caring for this communal herd, known as the *vecera*. All the 900 or so sheep belonging to village families are taken to pasture in a single herd by a shepherd from the community.

These are customs that took form in the medieval era, when, in the words of historian Teofilo Ruiz, villagers "either worked together or died separately." They continue to be practiced today in small communities such as Santa María, where people are linked by kinship and close relations with their neighbors. Yet the older attitudes and forms of social organization persist only as fragments of what was once a unified cultural system. The land consolidation has doomed them to extinction, and they will pass away with the last of the old peasant farmers. □

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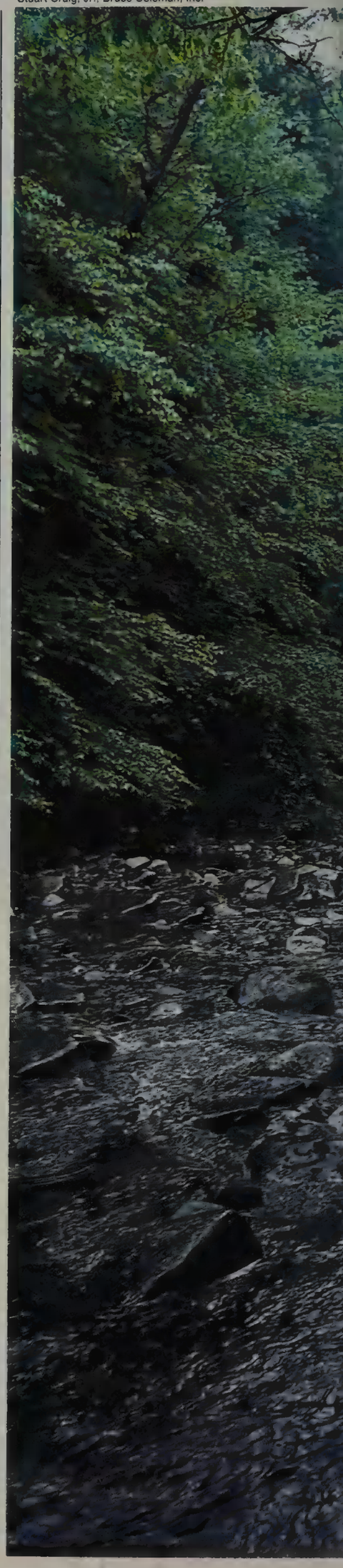

Ramsey's Draft, Virginia

by Robert H. Mohlenbrock

The timber in the western, mountainous part of Virginia was cut extensively near the turn of the century, and by 1910 very little of the original forest was left. Among the harvested trees were Canadian hemlocks, but they were not particularly valued for their wood. Instead, lumbermen stripped the tannin-rich bark from the trunks to sell to the tanning industry. Because the tissues that conduct water and dissolved nutrients lie in the bark, the mutilated trees soon perished. Today only a single stand of virgin hemlock forest survives in Virginia—Ramsey's Draft, in George Washington National Forest. Just a few hours' drive from Washington, D.C., and Richmond, Virginia, Ramsey's Draft is nestled below the summit of Shenandoah Mountain, where the ruins of Confederate breastworks still stand.

The name Ramsey's Draft attracted me long before I was able to visit the place itself. One of the definitions of *draft* is "gorge," and I had little trouble envisioning a deep ravine filled with stately trees and colorful mountain flowers. Looking at a geologic map, I noted that the creek that has carved the draft through centuries of cutting and washing is named Ramsey's Draft Run. *Run* has an air of excitement about it that is not usually conveyed to me when I hear the word *creek*.

Ramsey's Draft is a lush ravine nearly one thousand feet below Shenandoah Mountain to the west and Bald Ridge to the east. Through the ravine, Ramsey's Draft Run tumbles and sparkles over a bed of smooth, polished rocks. The waters that feed the run come from temporary rain-fed streams, mountainside springs, and a major tributary known as Jerry's Run, which begins as a trickle high up on Shenandoah Mountain. A primitive, dead-end road once followed Ramsey's Draft Run for nearly five miles, but in 1972, Hurricane Agnes washed away some of its stone fords. Today, this route is the main basis for a hiking trail that begins at a parking area off U.S. 250.

The trail wends its way upstream, crossing the run sixteen times. For the first two miles, the trail climbs imperceptibly from 2,252 to 2,914 feet, where Ramsey's Draft Run forks into the Right Prong and the Left Prong (the Left Prong is Jerry's Run). The forest in the ravine bottom is deeply shaded by thick stands of coniferous Canadian hemlocks and white pines, occasionally punctuated by deciduous trees—cucumber magnolia, American beech, shagbark hickory, and red maple. Mountain laurel adds a dash of color during June, while witch hazel, whose woody seed capsules explode with a sharp cracking sound in autumn, hangs gracefully over the run in several places.

Records indicate that the forest along the first two miles of the run has not been timbered since shortly after the turn of the century. But the part of the forest that has never been cut lies beyond the fork of Ramsey's Draft Run, stretching for three miles along the Right Prong. It was probably spared because of its remoteness and because its previous owners appreciated its magnificence. This virgin forest contains Canadian hemlocks nearly 150 feet tall and up to 4 feet in diameter. Occasional specimens of broad-leaved yellow and gray birches provide a contrast to the dark green needles of the hemlocks.

Canadian hemlock is common in the Maritime Provinces of Canada, as well as in much of New England, northern New York, and western Pennsylvania, but it also occurs in isolated areas as far away as southern Indiana and northern Alabama. During its early years, the Canadian hemlock is shaped like a broad-based pyramid. The long, slender branches on the lower part of the trunk are usually horizontal or even pendulous, while those higher up are ascending. In the dense shade of Ramsey's Draft, however, the lower branches die off after a few years, leaving the trunks nearly naked for up to two-thirds their length. Except for a dense covering of the evergreen spinulose woods fern on the forest

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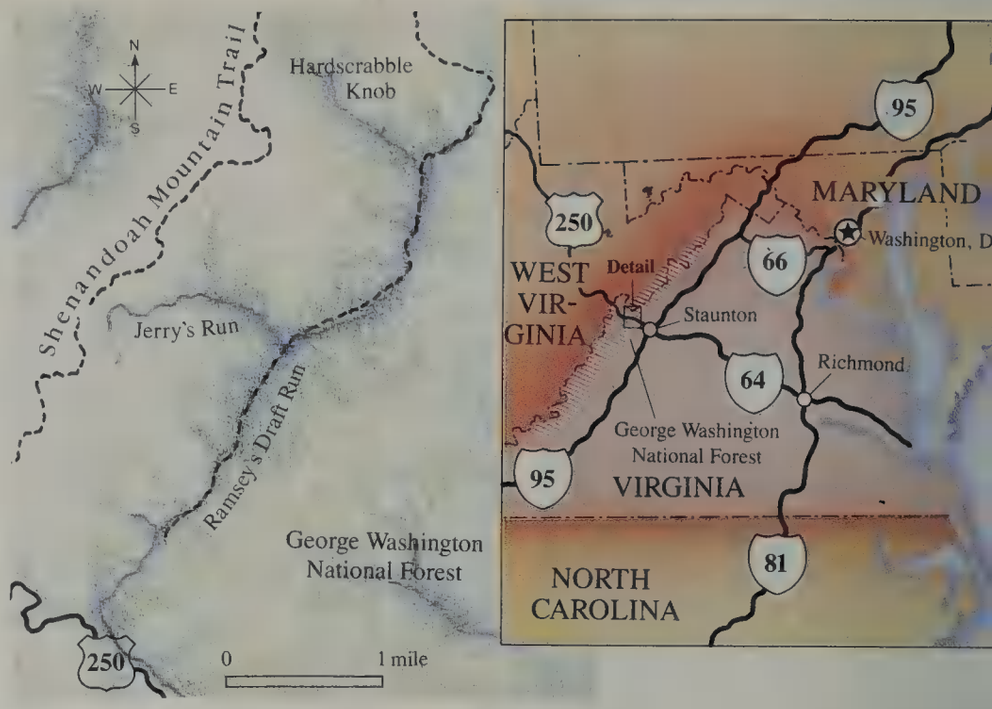

Joe LeMo

Ramsey's Draft

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floor, there is little underbrush, so there is an extensive view through the forest, interrupted only by the large tree trunks.

The hemlock's bark, often cinnamon red, contains high concentrations of tannin, which discourages insects. The tree's flat, narrow leaves, each less than one inch long, are arranged on the branches in flat sprays, giving each leaf maximum exposure to the limited sunlight. Individual leaves persist on the hemlock for three years. They emerge from tiny buds a light yellow-green, but during their first year they become deep green and shiny.

In early May, millions of yellow pollen grains develop in small, spherical clusters at the base of the year-old leaves. While most of the pollen falls uselessly to the ground, some lands on the hemlock's erect, green, ⅛-inch-long female "flowers." Self-pollination is unlikely because a tree's female parts do not mature until a few days after pollen is released. Following pollination, tiny cones begin to develop. By the end of the year, they are three-quarters of an inch long and hang gracefully on slender stalks. Most of their seeds fall during the winter and are dispersed on transparent wings by the wind.

Although each mature hemlock produces thousands of seeds annually, only those that land in dense shade are likely to germinate. If there is an opening in the canopy left where a giant tree fell, the forest floor is more conducive to the germi tion of maples and other tree species. ter a few years, however, as the can closes overhead, the seedlings of th other trees die. As long as the hemlock Ramsey's Draft are protected from lu bering and fire, other species will not g a significant foothold.

While the spinulose woods fern do nates the forest floor, several mount wildflowers occasionally emerge throu the fronds. The delicate bloodroot and s eral kinds of white and purple violets the first to bloom in the spring, follow by jack-in-the-pulpit, cucumber root, S omon's seal, and clintonia. In summer, dainty enchanter's nightshade puts fo its tiny white flowers. As the trail cont ues ever higher along the Right Prong, casional patches of flame azalea and r azalea fill in the shrub layer of the fore

After passing through the virgin he lock forest, the trail climbs 1,400 feet less than two miles to Hardscrabble Kn The knob is very steep and covered w loosely packed gray and green fossil-be ing sandstone rocks. Hiner Spring, wh feeds Ramsey's Draft Run, seeps ou few feet below the summit. The hu shade-forming trees found at lower ele tions are absent on Hardscrabble Kn With more sunshine, red maples a black, white, and red oaks become co mon and thickets of black huckleber and an abundance of May apples, yell star grass, wild geranium, and oth wildflowers grow beneath the trees.

"This Land" highlights the biologi phenomena of the 153 U.S. national f ests. Robert H. Mohlenbrock is dist guished professor of botany at South Illinois University at Carbondale.

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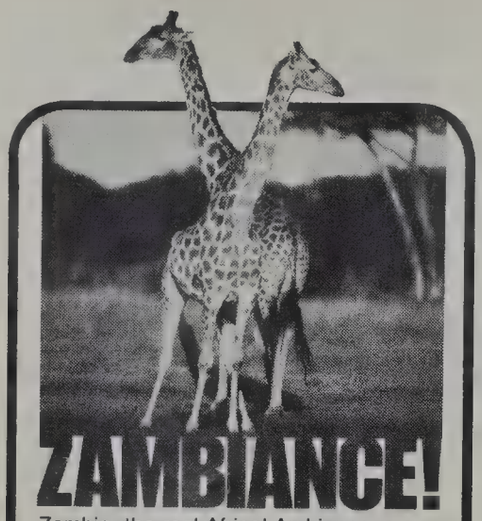

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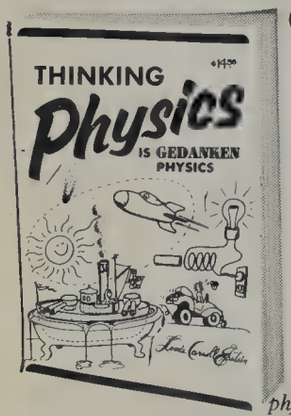

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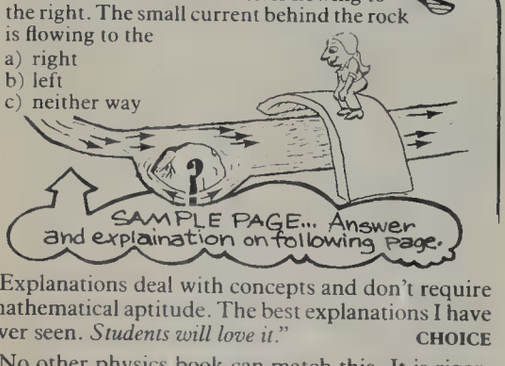

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The Unportable Field Guide

by Michael Harwood

There's not the slightest doubt in my mind that video cassettes represent the next "great leap forward" in the genre denominated field guides, particularly field guides to the birds. But even if you have $74.95 just burning a hole in your pocket during the Christmas rush, do not invest your money in this "video guide" as a gift for your favorite birder. It will disappoint the experienced bird chaser and confuse and frustrate the novice.

Within a few years the equipment for playing video cassettes will be as miniaturized and portable as battery-powered audio cassette players are today, and we'll be able to carry our video-playing gear with us as we race across a mud flat after an unfamiliar shore bird. Now, however, this video guide must be used either at home or in some handy Winnebago.

AUDUBON SOCIETY'S VIDEOGUIDE TO THE BIRDS OF NORTH AMERICA. *(cassette 1); $74.95 in VHF and Beta.*

But imagine what a television guide to the birds could do even today if it were well put together. First, it could be a superb teacher. It could do what no book can—show each species in characteristic motion and simultaneously let the viewer hear a representative variety of vocalizations. With repeated replays you could spend as much time as you wanted watching and listening to an unfamiliar species—and at close range—until you had it nailed into your memory bank.

In cases where males of the species differ in appearance from the females, the videotape could display a living, breathing pair together—feeding, courting, or whatever else shows off the differences well. It could present adults and young in various interesting stages of plumage and activi It could show characteristic behavior th would help a birder learn to identify t species—a flock of white pelicans spir ing up on a thermal, for instance, or a male northern goshawk on the wing, reening through a thicket as she charg an intruder that had approached her ne too closely. It could do a great many su things. And simply by being a sheer light to watch and listen to, it would pro elytize for the protection of birds a thereby of the world's environment.

But what do we have here? We have video show that mostly emulates a pri field guide instead of going beyond it. Th video guide was written, directed, and na rated by Michael Godfrey, son of the la Arthur Godfrey, and coproduced by Go frey and Richard Stadin, president MasterVision, Inc., which distributes Godfrey has had access to the definiti audio library at the Cornell Laboratory Ornithology, and with the help VIREO—the top-of-the-line, pioneerin photo archive at the Academy of Natur Sciences of Philadelphia—he has draw on a large collection of bird photograp by such luminaries as Eliot Porter, Alfre Eisenstaedt, Olin Sewell Pettingill, J and others. Roger Tory Peterson, king the printed field guides, provides the intr duction. The completed video guide wi run *eight* hours and will be sold in four se ments, each to be priced, presumably, $74.95 or more. This flagship segment— the first two hours of tape to be released— deals with the loons, grebes, pelican ducks, geese, diurnal raptors, and chic enlike birds of North America.

It is, unhappily, not a rich collection exciting cinematography and videotape birds in life. To be sure, motion segment are scattered throughout it, but less than

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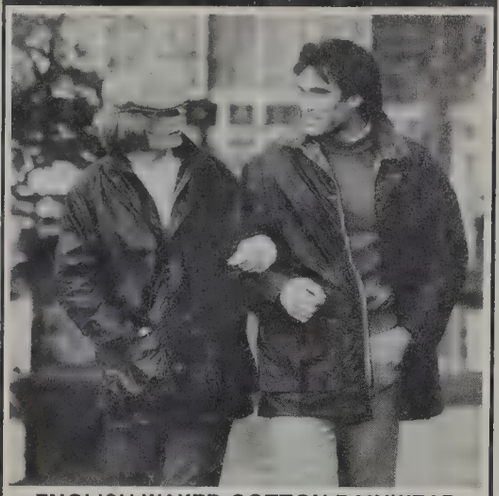

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third of the individual species descriptions include moving pictures. A few sequences are tantalizingly good; the courtship dance of the western grebes springs immediately to mind. But many of the sequences are only snatches, about one to three seconds long. There are also selections of bird calls for many—but far from all—the species shown.

In short, there's not nearly enough of the sort of material that could make this video guide exciting and unique. It is at heart a collection of still photographs and range maps that are displayed on the screen while Godfrey reads an abbreviated text. Its resemblance to a print field guide is inadvertently heightened by the Peterson-style indicators that point to key field marks on the bird photographs.

The annual index for
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It doesn't even do much of a job as a dressed-up print field guide. Start with the visual aspects. The stills may often be great as photographs, but if you are going to display birds in frozen poses instead of in motion, photographs, by their nature, are far less helpful than drawings as aids to identification. The people who have chosen to illustrate field guides with photographs argue that photos are better than drawings because they show real birds, not idealized ones. But most bird photographs contain too many distractions and distortions of reality—tricks played by angle and perspective, light and shadow, film-stock and processing—to be truly representative of any subject species as a whole.

In this video guide, for example, while the narrator's voice-over is describing the "orange-red" face mask—actually the facial skin—of the red-faced cormorant, the viewer is looking at a photograph of a cormorant with a *canary yellow* mask. Flaws of that sort may be the result of a seasonal variation in the species concerned or an idiosyncracy of the individual bird or the result of the process that produced the original still photograph. Who can tell? In any case, the photographs are misleading, and a good many of them appear out of focus. These complaints could be blamed on the viewing equipment, so let me add here that I watched my first run-through of video guide at the home of a former work radio and television engineer keeps up to date on developments in tel sion equipment, and the television set used was a model well known, accord to my friend the engineer, for its faith color reproduction and sharpness. friend also pointed out that at the be ning of the tape the narrator urges view to check the color balance of their sets, the producers haven't offered color bar the start of the tape to make checking adjusting possible, so viewers wh equipment isn't properly color balan are going to be even more unhappy w the colors than I was.

The narrative is no better than mostly static illustrations. It is humdr and terse, and partly because of the s plification enforced by brevity, it inclu some questionable (or worse) infor tion—for example, that the blue-win teal "nests in prairie potholes," whic does not do in the prairieless New Engl and Atlantic coast part of its range, that the population of the trumpeter sw once dropped to as few as sixty-six indiv uals (when that swan count was made 1932, most of the trumpeter's nesting wintering areas were still unknown to ence, so the counters censused only a sm fraction of the actual population—and fact, they found sixty-nine, not sixty-s The text is not well matched to the vis effects. The viewer may be looking at aspect of a bird while Godfrey is talk about another aspect altogether, whic very distracting. The narration also peatedly highlights the paucity of mot on the visual side—for instance, menti ing, but not displaying, the shall wingbeat of the red-tailed tropicbird. A watched, I was more than once moved shout at the invisible narrator, "W *show* it, for heaven's sake!"

The old writing rule about showing stead of telling applies particularly wel a television production, and the miss opportunities here are legion. Except the bird vocalizations, which are ava able—and better—in commercial au tape collections, this video guide offers atively little more than what a bir could find in a good printed field guide certainly not 74 dollars and 95 cen worth more. Television is the next hi ground for bird identification aids right, but my advice for this Christmas spend the money on *books* about birds

Michael Harwood, who has written seve books on birds, is coauthor with his w Mary Durant, of On the Road with Jo James Audubon.

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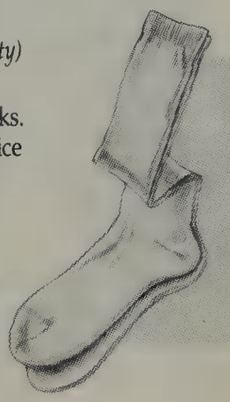

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Jungle Maintenance

by Marshall Schwartzman

For twenty years now, Ray deLucia has been cleaning Africa. Sixty-nine years old, bespectacled, and sporting a waxed handlebar mustache ("to let people know I'm the artistic type"), deLucia, chief preparator emeritus of the Museum, has been restoring the habitat groups of the Akeley Hall of African Mammals one by one.

As originally conceived by Carl Akeley, Museum explorer, taxidermist, and preparator, the hall was to be a monument to the wildlife of Africa. By the second decade of the twentieth century, the "great white hunters" of Europe and America and the spread of agriculture were already threatening Africa's big game with extinction. Akeley lamented this prospect in a 1926 letter to the Museum from Africa: "I have not appreciated the absolute necessity of carrying on the African Hall, if it is ever to be done, as I do now after this painful revelation. The old conditions, the story of which we want to tell, are now all gone, and in another decade the men who knew them will all be gone."

A few months later Akeley died of dysentery in Africa. But he left behind plans and blueprints, realized ten years after his death as the hall that bears his name.

The presentation of Akeley's twenty-eight habitat groups in specially designed cases, known as dioramas, marked a chance marriage of the work of two M seum pioneers. In 1902, while Akeley w still at the Field Museum in Chicag Frank Chapman, a colleague at the Am ican Museum, was busy designing a n means of displaying birds. As a young b Chapman had visited the Museum learn more about the local birds he h seen in his native New Jersey. But found he could learn little from the d plays in the Museum; specimens we mounted as solitary trophies on the wa or thrown together in display cases. Bir from disparate parts of the world or fro widely differing climates might be fou together in the same group, and there w little, if any, attempt to place the exhibit its natural environment.

When Chapman was hired by the M seum in 1888 as an assistant curator of nithology and mammals, the placing birds in groupings as they would be seen the wild had already become popular the Museum. These arrangements repr sented an advance over the haphazard, rio-cabinet-type of display Chapman ha seen on his childhood visit. Although was an improvement, this second gener tion of displays still lacked the realist foregrounds and backgrounds that wou set off the animals. Chapman's sugge tions gave birth to the first complete hal

The bongo group on the first floor of the Akeley hall

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tat group at the Museum—the Cobb's Island group. Chapman added a concave background mural to enclose the entire display space behind a glass front and set it in a wall. Within this space, Chapman set breeding terns on a shell-strewn beach, which receded into the background mural and created the illusion of three dimensions. The effect was that of a window into nature, and the object, as Chapman later said, was to present the subject "in such a manner as to render apparent the bird's place in nature and its relation to man."

The diorama method of display quickly became a favorite of curators and the public alike. The three-dimensional, naturalistic presentations offered viewers an unprecedented experience in museum-going. Nothing in the Museum approached the dioramas' aesthetic appeal and educational value, and crowds came to see the new exhibits in record numbers.

This was just the type of prominence and striking realism that Akeley envisioned for his collections, and the dioramas created for the African hall were the finest examples of their kind. Although previous Museum dioramas had achieved their aim of scientific accuracy, few reached the level of realism Akeley demanded. Often the mural painters lacked the skill to create the illusion of three dimensions on a flat canvas and the foreground and background were imperfectly integrated, leaving a sharp line where t foreground ended and the mural bega

So where some dioramas in other ha made do with a flat background mu and one, two, or even three glass sid (making them more like cases than dio mas), every display in the Akeley hall w a fully enclosed and realized natural s ting. Specially selected and trained arti re-created exact locations, seasons, a time of day. More than ten years we spent collecting specimens—from zebr and giraffes to gemsboks and okap Boulders and trees that couldn't brought back from Africa were sketch or photographed in the field and later created in the Museum. The method preparing the mountings had been devis by Akeley. Previously, skins had be stuffed with almost any material at ha (straw and cloth, for example). T Akeley method started with a clay mod of the animal sculpted onto the posed sk eton and anatomically correct to the la muscle. From this a plaster model w cast and the hide fitted, creating a mou ing unparalleled in terms of form. T Museum sometimes spent up to $50,0 on a diorama (it would cost at lea $100,000 to build the same diorama day).

For all their care and attention to deta though, the designers and builders of t Akeley hall could not protect their c ations from the effects of time, and by t early 1960s, the dioramas were showi signs of age. Dirt accumulated on t background murals, dust settled on t mountings, leaves drooped and shrivele and the brilliant colors of the anima hides faded. Something had to be don and for the first time in thirty years the oramas were opened. To do the work, t Museum turned to Ray deLucia, one the few people still alive who had work on the construction of the dioramas.

Beginning with the oldest groups—t gorilla habitat and other dioramas on t first floor—deLucia, and later Steph Quinn, an artist-preparator with the M seum, set to work. Once the 8- by 14-fo pane of glass that enclosed the exhibit w removed, the lush underbrush and mou tainsides of the Kivu volcanoes of We Africa beckoned. DeLucia entered t place that Akeley had once called "t most beautiful spot in the world." But had to tread carefully. "Once you get there, you think you're in the jungle," sa deLucia, "but you have to know whe you can step and where you can't."

Airbrush in hand, deLucia ginger made his way along a path leading dow the mountainside. Beginning with t foreground, he cleaned the foliage a

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The four corners of the Akeley hall ha the largest, most exotic dioramas. The three Grevy zebras above are part of t water hole group.

mountings, careful not to damage the de cate and sometimes brittle models. A sol tion of detergent and water removed th dust and grime from cotton and wax doo plants and pendent ferns. In the center the scene, a large blackberry bush ha shriveled from years of neglect. With hot-air gun, deLucia directed a steac stream of heat at the leaves, which r sponded like newly blossoming flowers. T his right, he doused a small female goril munching on wild celery, and farth down the path, a rare mountain squirr hidden in a lichen-covered tutsan plan To his left, he aimed his airbrush at a fea some male gorilla beating his breast.

To reach beyond the jungle floo deLucia constructed a raised wooden pla form on stilts, just high enough to clear th gorillas. From there he sprayed the tre limbs that hung above the scene and ap plied the detergent mix to the sky an background murals.

After about a month, the gorilla grou was renewed, and deLucia moved on t the adjoining Libyan desert scene. Here there was no nettlesome foliage to clean o repair, just a trio of addax antelopes, scimitar-horned oryx, and an addra ga zelle foraging on a leafy green deser plant, set against a sandy landscape punc tuated by a few rocks. After a simpl

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ning, a new light box was installed to ce heat, the greatest enemy of the di-nas. Heat fades the pigments of hides, es dust into the murals and the ani-s' fur, and causes plants to wither. t of this heat came from giant incan-cent bulbs, which were the standard ns of illumination in the 1930s. Since , cooler fluorescent lights have be-e the prevailing means of lighting n displays, and as a matter of course light boxes in each of the dioramas e rebuilt to incorporate these fixtures. y combining incandescent and flu-cent types of lighting, the artists were to make the settings more dramatic. fluorescent lights brought out the , even light of the African sky, while incandescent lights, with their strong, used rays, cast shadows and created illusion of sunbeams. But once this light box was installed in the Libyan up, an entirely new problem appeared: even light of the fluorescent bulbs cast adow under each of the antelopes, but dows were only supposed to appear to side of each animal, simulating the ef-t of the setting sun. Luckily, the sand s not real but plaster, and deLucia was e to paint out these unwanted shadows. as he might, though, he could not nt away the shadow cast from the hind arters of the largest of the addax. Not to be defeated by a mere shadow, Lucia painted a new bush on the mural he shaded spot and molded a new rock place before the bush.

Such artful innovations served deLucia ll during the course of the restoration. w samples of soil cannot be obtained m Africa for every faded patch, and

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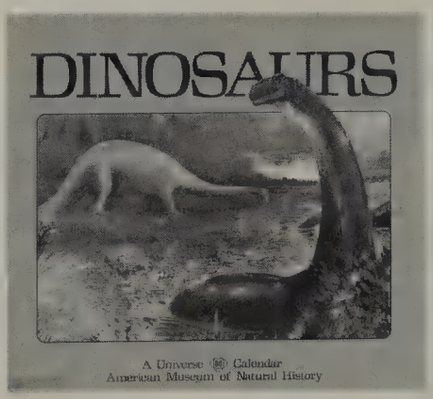

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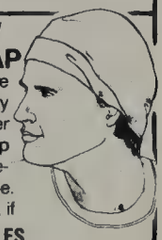

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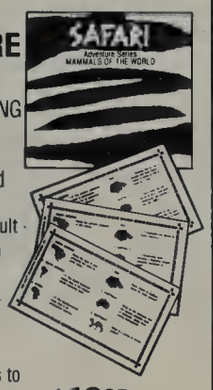

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new plants cannot be created just to r
place a few shriveled leaves. Instead
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hidden nook or cranny, and damage
leaves are simply cut off. And sometime
as deLucia says, "You have to inver
things or make things up as you go along.

For the bongo group, a deep-jungl
scene of large, spiral-horned antelope, h
had to do just that. A recessed light box i
the rear simulated sunbeams shining int
the background of the setting, but th
original artist had left unpainted two fe
of sky from the edge of the box to the mu
ral. DeLucia had an idea. First he painte
the unfinished portion and filled in th
open space with leaves and branche
made of paper and chicken wire. Then h
cut tin cans into the shapes of leaves an
integrated them into the new canopy t
catch and reflect the spotlights—effe

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Ghost Stories

Master storyteller Laura Simms an
musician Steven Gorn return to the Mu
seum with a Halloween program of super

y creating the illusion of sunlight mering through the treetops.
this way Ray deLucia and his assis- have revitalized the dioramas of the ey hall. The Museum still has to e emergency repairs from time to ; seasonal expansion and contraction e walls crack the murals, burst pipes e water damage, beetles infiltrate the ays and chew on the protein-rich hide ountings, and an occasional mouse es its way into a setting, leaving be- its signature droppings across a nt white patch of snow. But thanks to man with the waxed handlebar mus- e, in a small corner of the Museum, ors may still find "the most beautiful in the world."

shall Schwartzman is a staff member of ural History *magazine.*

ral tales. Performances are on No- ber 2 at 1:30 and 3:30 P.M. (family ram) and 7:30 P.M. (for adults). Tick- which must be ordered in advance, are 0 (children) and $3.00 (adults) for nbers and $4.00 for nonmembers. For rmation call (212) 873-1327.

erial India

s part of this year's Festival of India, Museum will present *Vijayanagra: ere Kings and Gods Meet,* forty photo- hs and drawings of the best preserved ndia's imperial Hindu capitals. This bit runs from October 23 to January n the Akeley Gallery.

ther Side of the Rainbow

he November family program for nbers is *Another Side of the Rainbow,* uring the Rainbow Road Dancers. ee performances, geared toward chil- n five to twelve years old, will be given 1:00 A.M., 1:00 and 3:30 P.M. on Sun- November 24. The program is free members and $2.50 for nonmembers. information call (212) 873-1327.

nan and Animal Behavior

tephen Jay Gould, Sarah Hrdy, and Skinner will be panelists on Friday, vember 8, in the third annual T.C. neirla Conference, *Evolution of So- Behavior: Integrative Levels.* They discuss correlations between human animal behavior from scientific, so- , and philosophical viewpoints. The gram starts at 8:00 P.M. in the Audito- n. Tickets are $4.00 for members and 00 for nonmembers. Also scheduled nine specialized sessions for scholars,

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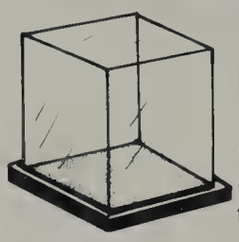

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Come Into My Parlour

The November member's program f tures photographer and filmmaker Jo Cooke, who will show his film *Come I My Parlour* on Wednesday, November at 7:30 P.M. in the Main Auditorium. T film captures spiders as they spin webs all shapes and sizes, hunt and trap prey, mate, molt, and become the host the eggs of others. The program is free members and $3.00 for nonmembers. P registration is required. For ticket formation call (212) 873-1327

Gem of a Weekend

The Education Department, in coop ation with the Gemological Institute America (G.I.A.), will sponsor a semi on gemology from November 15 to Two G.I.A. instructors will present l tures, films, and slide shows on how identify gems, and on the origin, sourc and mining of gemstones. The weeke begins with a social hour on Friday, N vember 15, at 7:00 P.M. at the Museu Sessions on Saturday and Sunday, N vember 16 and 17, begin at 10:00 A.M. a end at 5:30 P.M. The cost of the seminar $190 per person (including lunch) for p ticipating, donor, and contributing me bers and G.I.A. students; $215 for as ciates and others. For information c (212) 873-7507.

Fables from Far and Near

The Education Department prese *Fables from Far and Near,* a program tales from Africa, the Caribbean, a Black America, on Sunday, Novemb 10, at 2:00 and 4:00 P.M. in the Kaufma Theater. Kwame Nkrumah, a native Ghana, will tell tales of Africa; Cheryl B ron, an actress from Trinidad, will tell story from the Caribbean; and Yochev Bat-Imedt will tell Uncle Remus stori The program is designed for children a their parents.

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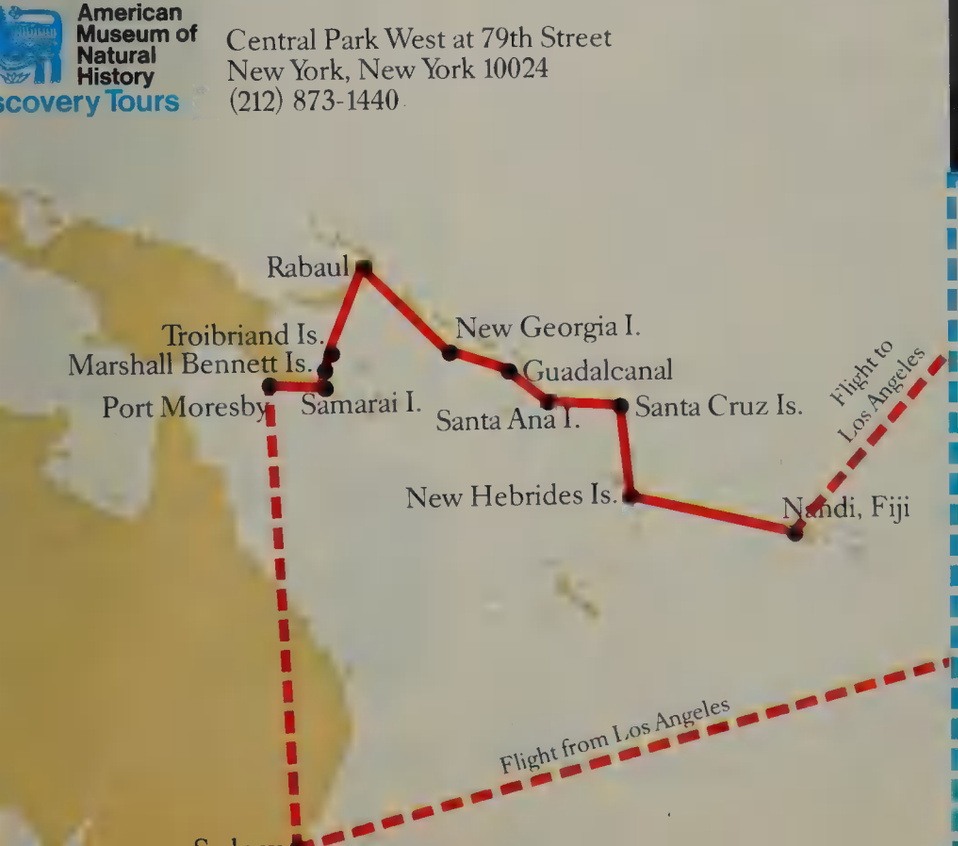

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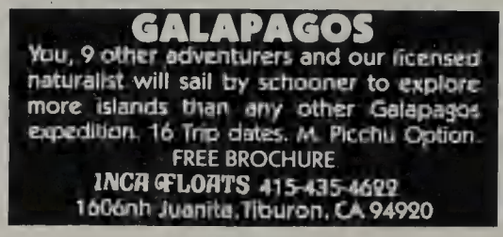
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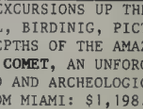

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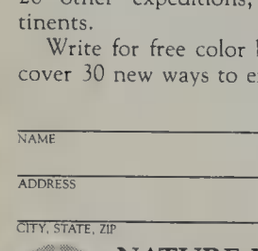

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Jupiter Stands Out

by Thomas D. Nicholson

The planets become increasingly difficult to observe this month as they gather around the sun. Jupiter is the only planet easily seen; actually it is hard to miss. Look for the brightest starlike object in the sky after dusk. Jupiter shines prominently in the south after sundown, setting in the west-southwest before midnight. The planet makes an attractive scene with the moon on the 17th amid the bikini-shaped star group in Capricornus.

During November, Mercury and Saturn are both evening and morning stars but are not conspicuous as either. Venus was a good morning star earlier in the fall, but this month it rises only about one hour ahead of the sun and will thus be difficult to view. Mars, more distant to the sun's right (west), rises about four hours before sunup. Look for the planet near the brighter star Spica in Virgo in the southeast at the onset of morning twilight.

Many of the planets are not well placed for our viewing this month, but we can still enjoy the beautiful autumn constellations. The great Square of Pegasus passes high in the south during the early evening hours with Andromeda, Perseus, Cassiopeia, Cepheus, and Pisces nearby. Because of lengthening autumn nights, the bright summer stars linger in the west following sunset; in the east are the brilliant stars of Orion, Taurus, Auriga, and Canis Major, which will soon dominate our skies during the long cold nights of winter.

The following events are given in local time unless otherwise noted.

November 1: The gibbous moon, in Taurus, trundles above the horizon two hours past sundown. When it rises higher, a triangle of bright stars surrounds it: Auriga's Capella above; Aldebaran in Tau (look for the V-shaped Hyades) to its rig and below; and Pollux and Castor, t twin stars of Gemini, rising below.

November 3: The moon rises abo 9:00 P.M., near Pollux and Castor, closi with them during the night. Before daw it passes below Pollux, making the twin threesome.

November 5: Last-quarter moon (3: P.M., EST) is in Cancer but slides into L before rising in the east after 11:00 P.M

November 6–7: The waning cresce moon drifts through Leo, passing bright star Regulus while below the ho zon on the 6th. The view is best in t morning with the moon to Regulus's rig on the 6th and to its left on the 7th.

November 8: Mercury reaches greatest distance east of the sun. In the a tumn, however, the path of the planets the sky is at a very low angle with the ho zon at sunset, so Mercury will be near impossible to observe.

November 9: The moon helps in fin ing Mars in the dawn sky just below the l nar crescent in Virgo. The bright st Spica is even lower.

November 11: The crescent moon hid Venus from Earth (an occultation) abo 6:00 A.M., EST, for sky watchers south the equator. But viewers in the Northe Hemisphere can't even see the player much less the drama, since Venus and th moon will fade quickly in the twilight aft they rise.

November 12: Spring tides and a sola eclipse accompany the new moon (at 9:2 A.M., EST). Perigee (when the moon nearest Earth) comes about an hour ea lier and is bound to prime high tides t

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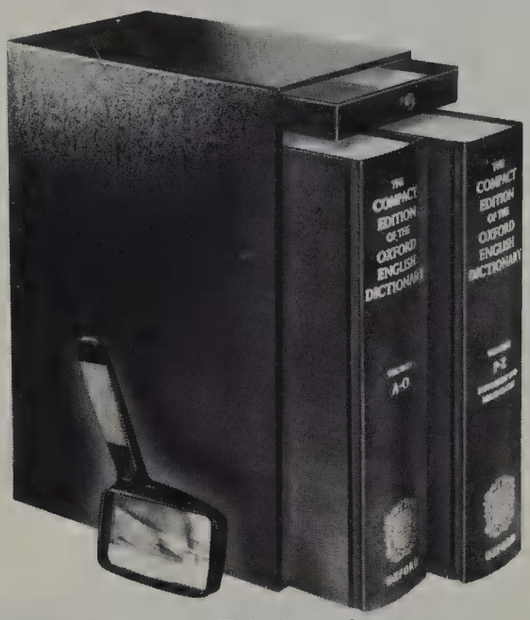

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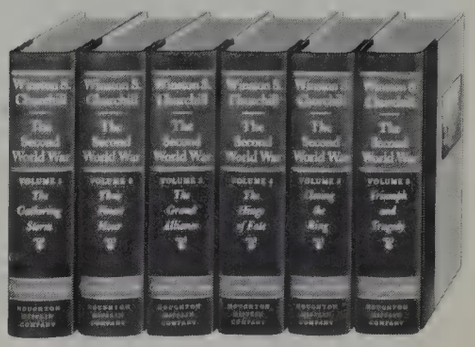

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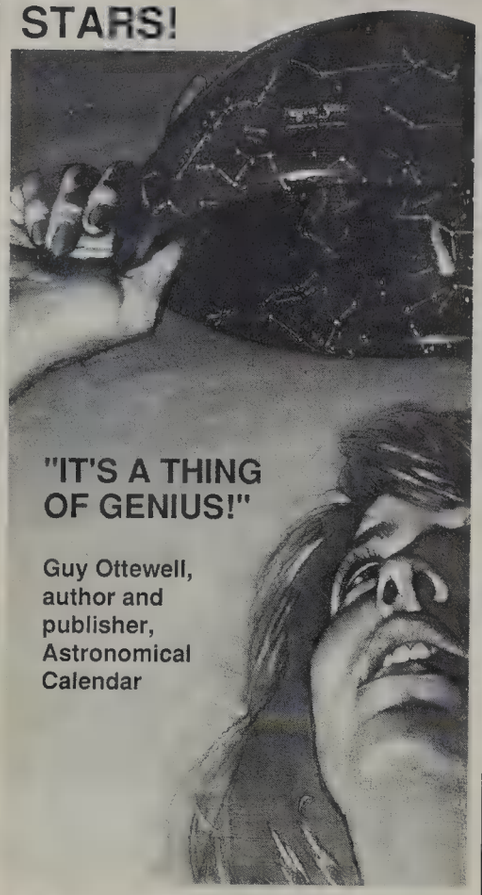

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night and tomorrow. The eclipse is austral, however, covering Antarctica and the waters around it, with totality limited to a small path in the South Pacific.

November 13: The moon occults Mercury in the southern Eastern Hemisphere, but the two are above the horizon only during daylight and twilight.

November 14: The young crescent moon appears in the evening sky, in the southwest at dusk.

November 16–17: If the weather cooperates, conditions will be ideal for the Leonid meteor shower. The moon sets early both nights. The shower usually produces up to fifteen meteors per hour from about 1:00 A.M. to dawn. They are often bright, bursting objects.

November 17: The beacon in the south all month is Jupiter, drifting into the west and setting before midnight. The crescent moon joins it tonight in Capricornus.

November 18: Mercury loops int retrograde path on the way out of the ning sky.

November 19: First-quarter moon (A.M., EST) is just over the border betv Capricornus and Aquarius.

November 21: The vernal equinox, known as the First Point of Aries, is above the moon, and the Square of P sus is above both.

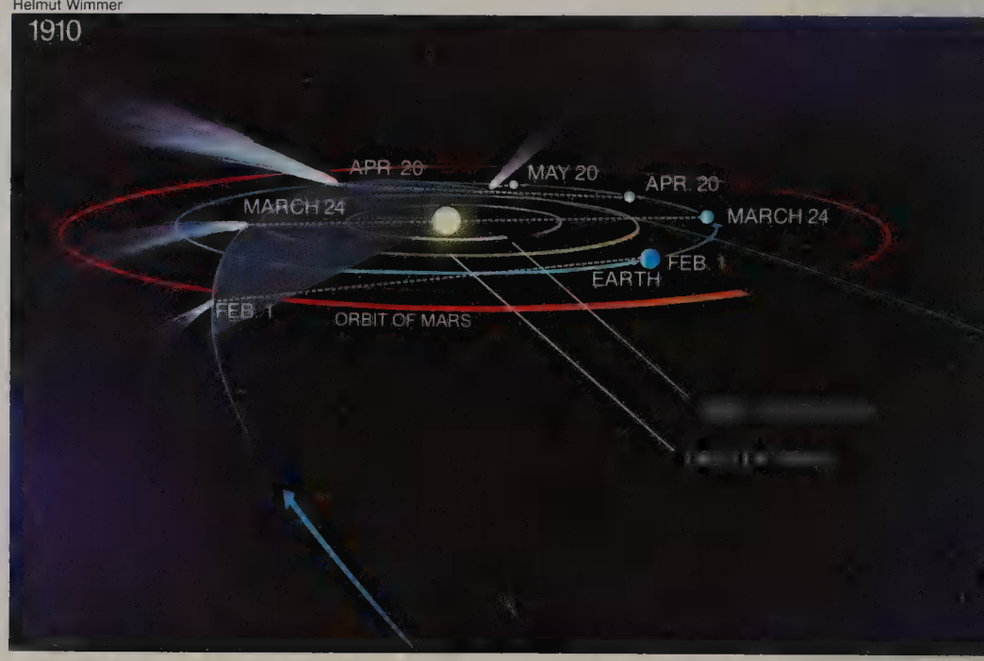
November 22: The sun moves east past Saturn. After coming in line with sun, the planet becomes a morning s

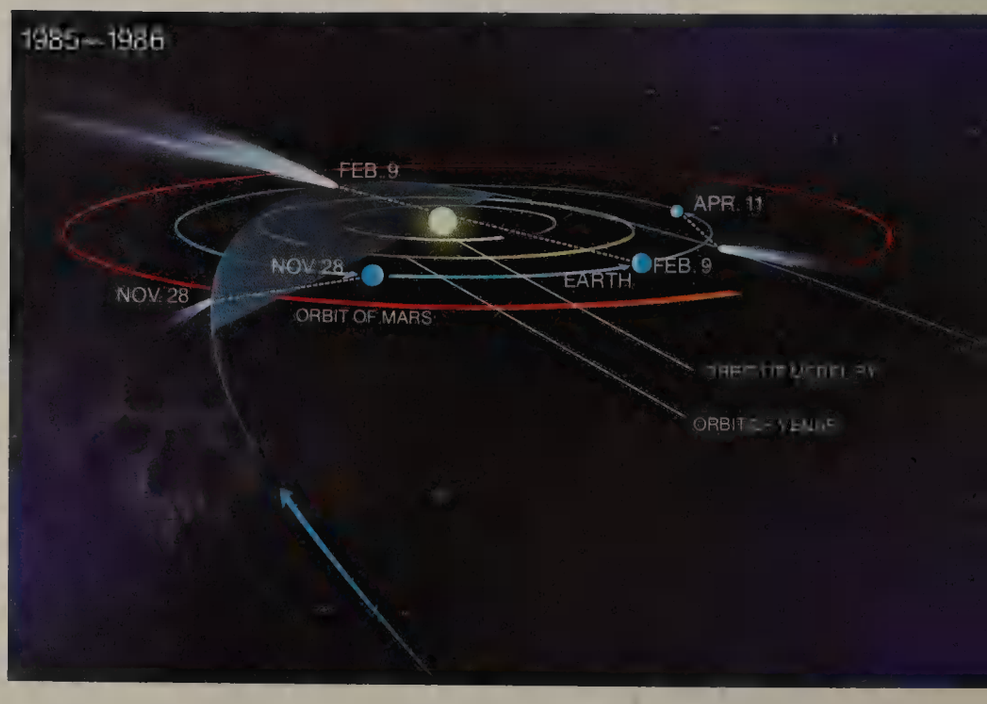
November 24: Sheratan and Ha the two bright stars of Aries the Ram above the moon tonight after it moves the constellation.

November 25: Apogee moon (fart from Earth) is still in Aries.

November 26: The gibbous moon ters Taurus again, where it was at the ginning of the month. The Pleiades

Helmut Wimmer





Sisters) are slightly above it and be dimly visible through the 's glare.

vember 27: The closest preperi- n passage of Comet Halley with n occurs today at a distance of 57 mil- miles. The comet is now closest to n on its journey toward the sun; an- (still closer) approach occurs in after perihelion. The comet is west moon, above the bright stars of Ar- The glare of moonlight, however, es the comet impossible to see with aked eye.

ovember 28: Mercury is in inferior unction, passing between Earth and un and entering the morning sky.

ovember 29–30: The bright gibbous n ends the month in Gemini, drifting r to Pollux and Castor on these eve- s, rising shortly after sundown and re- ing in the sky past dawn.

Halley's Comeback

ovember is an important month in the et Halley calendar. The comet passes e milestones in its journey toward the it moves north of the ecliptic plane on ember 9, comes closest to Earth on ember 27, and moves inside Mars's on November 28. Most important of the first "window" in its viewing dule begins, the one that favors thern Hemisphere viewers.

ost of the solar system's visible ele- ts (sun, planets, gas, and dust) are entrated near the ecliptic (the plane hich Earth orbits the sun). Most ob- move around the sun (and rotate) in ame direction, easterly (that is, coun- ockwise), as viewed from above h's North Pole. Some comets are out- ding exceptions.

ll comets that have been observed are lar orbits; their paths show no prefer- for the ecliptic plane. Except for a dred or so short-period comets cap- d in the inner solar system, the orbits hese celestial vagrants incline, essen-

In 1910 Comet Halley was fairly e to the sun when it passed the earth, diagram. That relative nearness ac- nts for its recorded brightness. This e around, bottom diagram, the comet pass the earth twice, but on neither will it be as close to either the sun or earth. That may cause the comet to ear dimmer.

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tially at random, all over the lot. They are as likely to move westerly as not. Thus it isn't surprising that Comet Halley curves toward us from a direction opposite that of Earth's revolution about the sun and on a tilted orbit.

For most of each solar journey, Comet Halley is well south of the solar system's principal plane. When farthest from the sun, it is 930 million miles south of Earth's orbital plane (ten times Earth's distance from the sun). It eventually crosses north of the plane on November 9, where it spends only 121 days of its 27,700-day orbital journey, climbing less than 16 million miles north of the ecliptic plane before returning south again on March 10, 1986.

On the way in from the outer solar system, Comet Halley moves past the orbits of seven planets, having started its present journey from beyond distant Neptune in 1948. It passed inside Neptune's orbit in the early 1960s, that of Uranus in 1977, Saturn's in 1983, and Jupiter's only ten days into 1985. Speeding up on its way in (now flying sunward at about 56,000 miles per hour), it still took more than ten months to reach Mars's orbit on November 28. Yet to come are Earth's orbit, which the comet will pass on New Year's Day, 1986, and that of Venus (January 20, 1986), before the comet "turns the corner" on February 9 to move away from the sun once more.

Each time Comet Halley goes round on this journey, it encounters Earth (moving in its own orbit) in different circumstances. Depending on where Earth is located, one or two points may occur during each comet journey when Earth and the comet come nearest to one another.

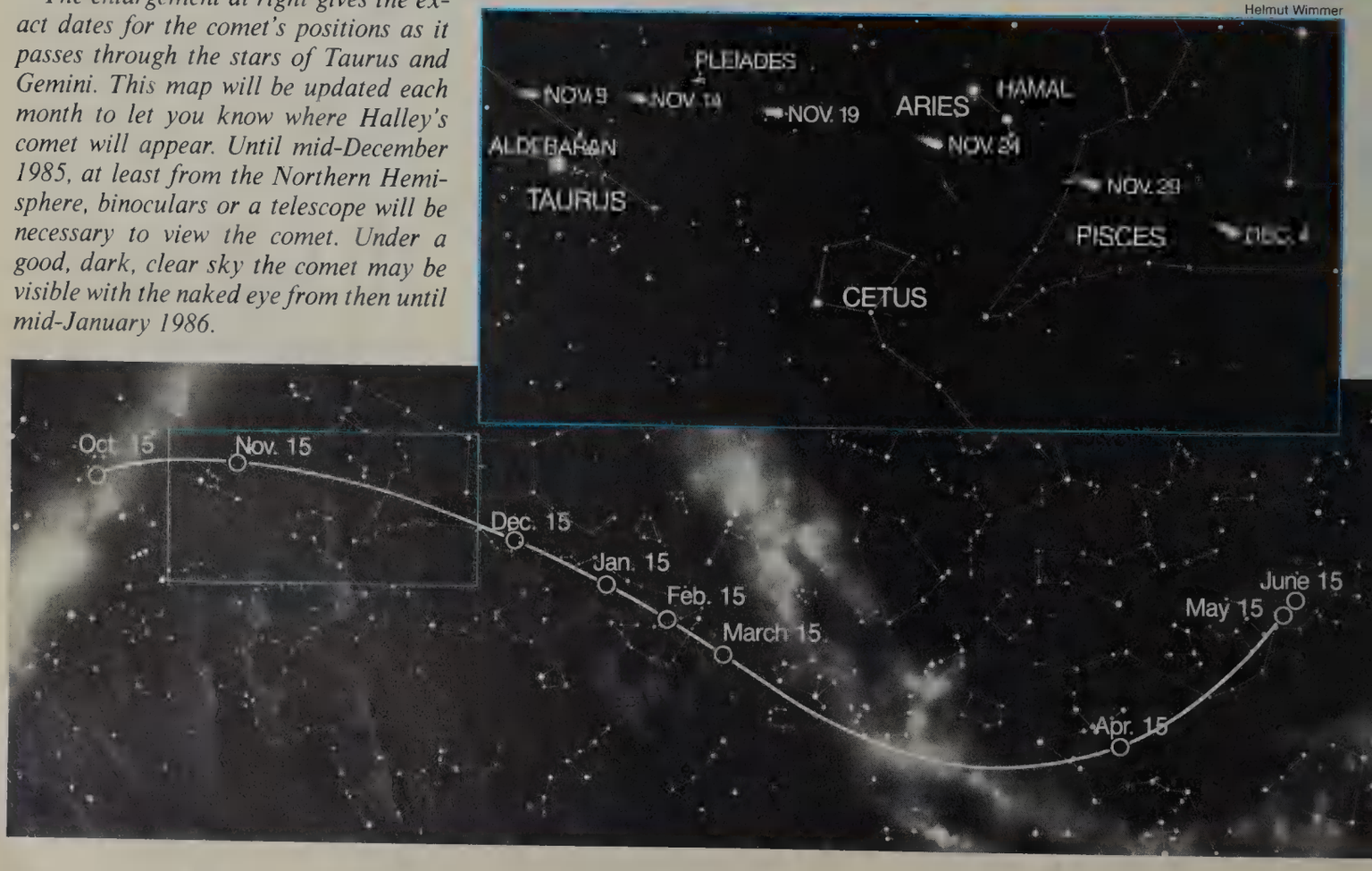
In 1910, Earth came within 14 million miles of Comet Halley less than a month after the comet had passed the sun. This single passage of the comet past Earth while it was still relatively close to the sun accounts for the comet's brilliant appearance that year. But the 1986 orbit of Comet Halley will encounter Earth quite differently. The comet passes close to Earth twice, once on the way in (November 27, at 57 million miles distance) and once on the way out (April 11, 1986, at 39 million miles distance). Both times the comet will be relatively far from the sun as well as from Earth, as compared with 1910. At or near the comet's perihelion on February 9, when it is brightest, Earth will be on the opposite side of the sun as seen from the comet.

On our close approach to the comet on November 27, Comet Halley will not have much of a tail, but it will be bright enough to be seen easily with binoculars. Thereafter, Earth and comet separate. As the comet approaches the sun it will continue to brighten, but at the same time its distance from the sun in the sky will decrease; thus the comet will spend fewer dark hours above the horizon. By mid-January, it will simply be too low at dusk to be seen no matter how bright it becomes.

From now until the middle of December, binoculars or telescopes will be needed. From then until mid-January, if conditions are good, sharp-eyed viewers should be able to pick out the comet in the evening sky with the unaided eye. This means clear, dark skies—no local lights or city glow, no obstructions in the western sky, and no moonlight. From the latter point of view, the best viewing periods will be from about November 30 to December 15 and again from December 31 to about January 15. At other times, the early evening moonlight will be an interference.

The diagram, below, traces Halley's path from left to right as it moves across the sky. The circles and dates indicate where the comet will be on the fifteenth of each month until June 1986, when it will have completed its journey around the sun. The comet will continue to fade from view, returning to interplanetary space.

The enlargement at right gives the exact dates for the comet's positions as it passes through the stars of Taurus and Gemini. This map will be updated each month to let you know where Halley's comet will appear. Until mid-December 1985, at least from the Northern Hemisphere, binoculars or a telescope will be necessary to view the comet. Under a good, dark, clear sky the comet may be visible with the naked eye from then until mid-January 1986.



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Dr. Leipoldt's Afrikaner Cookery

The gap between whites and blacks turns up even in a classic cookbook

by Raymond Sokolov

I have recently come into possession of *Leipoldt's Cape Cookery,* a scholarly account of Afrikaner cuisine, a hybrid of the very colonial culture now facing what may be its ultimate crisis. The author, C[hristiaan Frederick] Louis Leipoldt, was a prominent figure in South African life—a leading physician, a poet in both Afrikaans and English, a popular quiz-show personality on radio, a pundit, and a curmudgeon.

Born in 1880 in a remote mission station in Cape Colony, Leipoldt developed into an intellectual and a man of the world. The American press magnate Joseph Pulitzer once retained him nominally as his physician but really as a companion on his yacht. But Leipoldt did not turn his back on the Cape. And when he returned home from Europe in 1914, he resettled there, essentially for life.

Cooking, especially the traditional cooking of Cape Colony, became one of his chief preoccupations. He collected manuscript cookbooks and pored over early printed collections of recipes. Leipoldt made no claim and no serious attempt to be an anthropologist among the Zulu and Xhosas cooks of South Africa. He was interested in the food eaten by his own people in his own section of the country, where colonists adapted European food ideas, mainly those current in the early nineteenth century, to South African plants and animals and to the exotic methods of their Malay-run households.

Leipoldt published a cookbook in Afrikaans, *Kos Vir Die Kenner,* while he was alive, but he left a separate manuscript in English when he died in 1947. That manuscript was first published in 1976 and reprinted in 1983. Although the recipes did not pass through the hands of a home economist and do not list precise quantities of ingredients or specify cooking times or yields, it seems unlikely that Leipoldt's elegant little book will ever be surpassed as a record of a peculiar and fascinating frontier cuisine. Few people of Leipoldt's capacities have ever troubled themselves to write about food. He was, moreove witness, albeit a late one, to the flower of Cape cookery, and lived to see it star fade at the end of World War II. (Toda is experiencing a revival.)

Cape Cookery has a special interest American readers because it investiga and documents a colonial cuisine inven by and for colonizers in a rural soci where the white, European few domina the nonwhite, non-European many, b indigenous (blacks) and imported (M lays). In reading Leipoldt, Americans v inevitably think of the cuisine of the ar bellum South. Here we had the same c ative collision with new ingredients, same European culinary structure, same openness to new ideas from n white cooks.

The parallels cannot be carried mu further, certainly not politically. And terms of cuisine, we seem to have enc up with a heavy African admixture in c food, although the indigenous America were originally Asiatic, while the Afri ners adopted the spicy sambals of Sou east Asia, without taking much account native African recipes.

Nevertheless, white Americans will r ognize Leipoldt's admiring, but mora naïve, paean to his Malay "mammy":

My interest in cookery dates from the ti when, as a little boy in the late eighties the last century, I assisted in a very mi and suppressed capacity, at the culinary c erations of a very expert Colored wom cook who bore the reputation of being c of the best in the Cape Colony. Fat to t verge of obesity, she presided over a kitch whose cleanliness could have served as model for an operating theater of a mode hospital, largely because she insisted th punctilious, painstaking ablution was an dispensable preliminary in the preparati of food. Her inculcation of these eleme tary principles, often accompanied by good-natured but nevertheless pain prodding of my juvenile person with t large wooden spoon that was her scept helped me—in later days when I learned better my taste and broaden my expe

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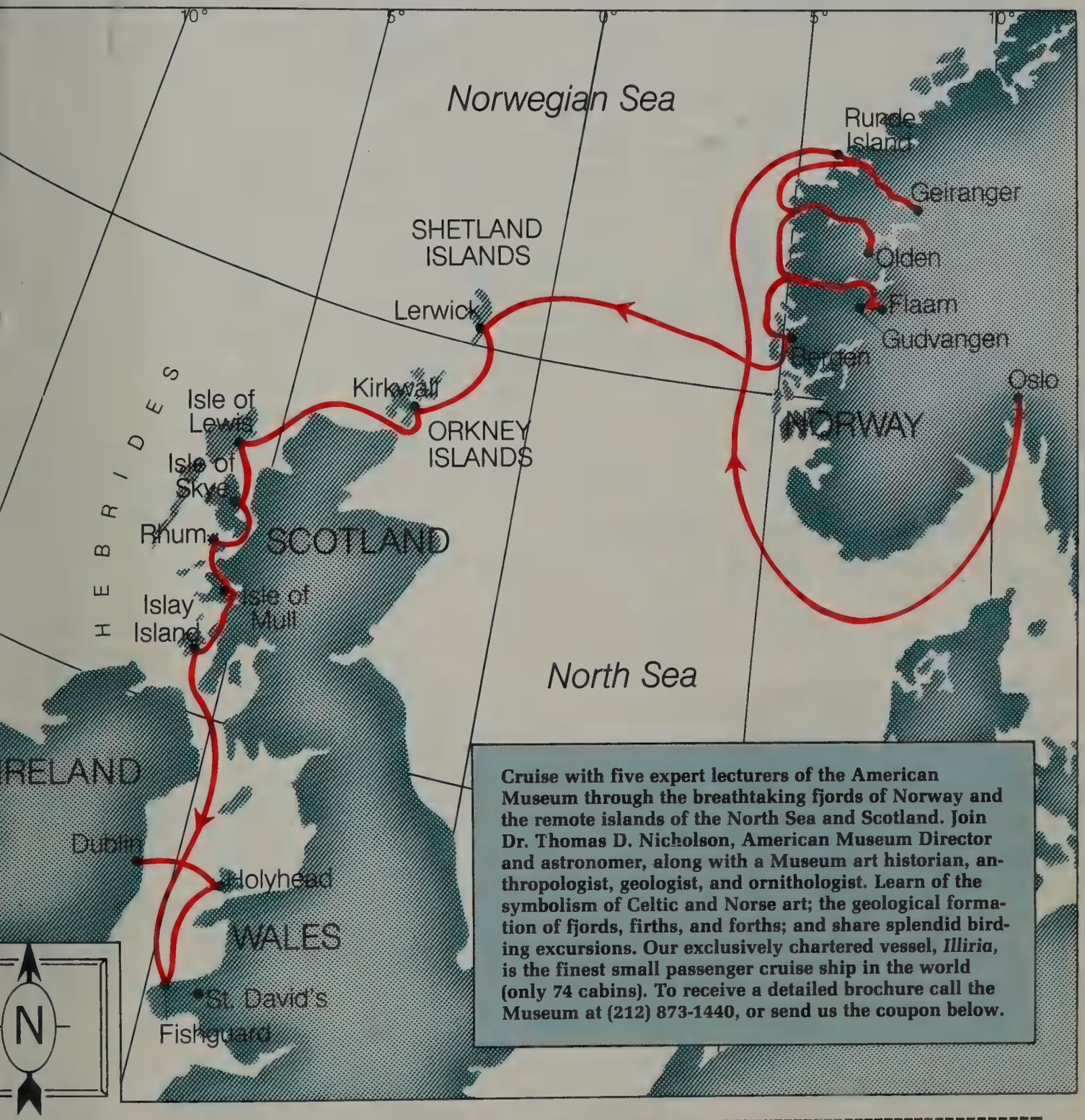

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ence—to realize how any infringement of them inevitably impairs the excellence of all cookery.

The ayah's art was the result of many years' instruction and experience in the traditional methods of Malay cookery, whose outstanding characteristics are the free, almost heroic, use of spices and aromatic flavorings; the prolonged, steady but slow application of moist heat to all meat dishes; and the skillful blending of many diverse constituents into a combination that still holds the essential goodness of each. Her dishes, which were eaten by governors, prime ministers, and very important persons, were made from old recipes that were firmly enshrined in her memory, for she never referred to written or printed directives.

Anyone wanting to get an idea of how the tropical Malay touch broadened and spiced the homelier, blander cuisine of northern Europe brought to Africa by the austral vanguard of the Dutch Reformed Church should take a look at Leipoldt's recipe for Jerusalem artichoke and banana or at his quince sambal (see below).

These recipes show the Asian ayah at work, turning the Mediterranean quince into a pungent relish and mixing the humble, earthy, crunchy Jerusalem artichoke with mushy, sun-yellow banana. All of this is as surprisingly un-African as okra gumbo—with its African beginnings—is un-American at base.

Leipoldt definitely strives to give the impression that Cape cookery is an imported hybrid: one part Dutch or Germanic with English infusions; the other Malay or "Oriental." Biltong, South Africa's famous jerked, or air-dried, meat, is traced to its Dutch origin as tassal. "O ental influence," he writes in his ch ter about the origins of the Cape cuisi "was predominant." Hildagonda Johar Duckitt, the South African Mrs. Beet spent her Victorian youth on a farm wh the cook was "an East Indian, an adept making curry and Malay dishes." M Duckitt's extremely influential bo *Hilda's Where is It?* contains, by L poldt's count, fifty exclusively South A can recipes, which "show the influence Oriental cooking methods, combined w local ingenuity in blending flavors and hancing the savor of the dish." But M Duckitt unaccountably failed, Leipo says, to include any recipes "manuf tured from ingredients that are essentia local—such as water hawthorn stew a the purées made from veld plants."

Nowhere in this chapter on the orig of Cape cuisine is there any mention "local" people, in Leipoldt's sense of t word. No black Africans play Squanto the sixteenth-century Dutch East In Company pilgrims, and blacks rema mysteriously absent from the book as whole. It is true that in Leipoldt's regi the Southwest Cape, blacks are even day a minority, but he shows no inter whatever in indigenous Hottentot fo Then again, perhaps the colonists stu bled on water hawthorn stew all on th own, not to mention the other wild and European, un-Asian, purely local fo that Leipoldt loved most.

Here he is, in his best, high-aesthet nostalgic vein, lamenting the passing o certain market in Cape Town:

In that cool, inviting colonnade, one co

Three Recipes from *Leipoldt's Cape Cookery,* by C. Louis Leipoldt
(W.J. Flesch and Partners, P.O. Box 3473, Cape Town 8000, South Africa)

Quince Sambal

Peel and grate a ripe quince. [It] should be snowy white.

Mix the grated flesh with lemon juice, powdered chili and white pepper and a little salt.

Porcupine Cracklings

Plunge the animal, as you would a suckling pig, into boiling water; scrape off the pens and the hairs; scrub the skin until it is perfectly smooth and white. Now skin the animal and discard the meat, which is not very nice to eat. Put the skin in a jar in salt water to which you have added a little vinegar, and let it lie in it overnight. Take it out the next day, dry it, rub it with a clove of garlic and put it in a saucepan with a little boiling water. Boil till it is tender enough to allow a fork to pierce it easily Take it out and cut it up into pieces abou the size of flattened apricots (about inches square) which you may either gri or fry in a pan with a little fat. Put on th pieces some pepper and salt and send t table with plenty of rice, and lemons cut i halves.

Banana Artichokes

Dice some [Jerusalem] artichokes tha have been steamed in wine; put the piece of artichoke in a saucepan, slice on then the bananas; add a lump of butter, a littl salt, pepper, and parsley; let them simme for a few minutes; add a glass of sherry and a little flour to thicken; shake well an add some more salt if required, and finall a cup of boiling thin cream. Serve wit nutmeg grated over.

most anything that one could think of
e kitchen—out-of-the-way herbs, tor-
and turtles; the tasty little "klip fish";
romatic berries that came from bushes
ing on the edge of the Green Point
mon Lake; the succulent fennel roots
made such delicious preserve; the de-
ful, but rather vulgar, rose apples that
folk liked to mingle in their sweet
es; the immense crayfish [langoustes or
lobsters] (the like of which one no
er sees, since Government has taken
under its protection and tried to teach
o call them crawfish); malagas eggs
re tasty than those of the penguin);
even that most delectable of all delica-
the prepared skin of a porcupine. [See
pe.]

is, of course, theoretically possible
none of these things was first discov-
by native Africans and passed on to
nists. But I doubt it. I especially doubt
the case of porcupine cracklings. And
e is the even more glaring case of
kos, wild food from the veld, that is,
a wild or uncultivated part of the
ntry.

Nothing could be more "local" than
e tubers and berries, these bulbs and
s. Can it be that their culinary use was
ned in every case by some clever Euro-
forager or by Malay slaves in their
-found land? This is the impression
oldt gives. Perhaps this happens be-
se in his scholarly way he limited him-
to written sources that ignored aborig-
cookery and food knowledge. And, of
rse, it may be that such substances as
(the seeds of the wild almond, *Brabe-
stellatifolium*) were independently
upon by natives and by colonists as
th roasting and then brewing into a co-
ike beverage called ghoo coffee. One
es, nevertheless, an omission here.
re are surely ways of looking beyond
ted sources and deducing which wild
ds were traditional in southern Africa
ore the advent of the colonist. It would
be interesting to know the modern so-
ogy of these indigenous foods. Who,
instance, were the workers in the road
gs at Grey's Pass, who allegedly, in
oldt's account, "lived mostly on ghoo
ns and a wine ration and did better
k than anyone else"?
might be persuaded that nothing men-
ed by Leipoldt in his charming and
ful book was eaten by black Africans
ore contact with Europeans. But then,
at did native Africans eat that was
quely theirs and why did Leipoldt ig-
e the subject?

*ymond Sokolov is a writer whose spe-
interests are the history and prepara-
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Up in Ontario

As a lumberjack, Wayne Lankinen generally focuses more on the trunks of trees than on their upper branches. But when Lankinen spotted a marten in a jack pine he was about to cut, he dropped his power saw and ran for his camera—telling the other jacks to keep the marten there until he got back. The marten, temporarily up a tree, started exploring the place and soon discovered a fellow inmate—a squirrel—above it. There was a brief chase; but by the time Lankinen got back, the marten had done to the squirrel what the lumberjacks had done to the marten—and everybody was trapped.

Actually, Lankinen was a little surprised to see a marten at all. They are rare in his part of Canada—the Thunder Bay section of Ontario—as they are in many places in the northwestern United States, Alaska, and Canada. The American pine marten used to be called American sable, and the creature was trapped intensively during the nineteenth and twentieth centuries. By the 1940s pelts were bringing as much as $100 each, but populations were way down. Regulations to protect the animal helped its population recover in many places. In some spots, however, it is gone for good.

The marten lives in pine forests. A relative of weasels, minks, and ferrets, it builds dens in hollow trees or logs. The marten is partly arboreal, although it spends a lot of time on the ground. It lives on small mammals, birds, insects, and fruit.

Lankinen got back in time to get this shot of the marten's encounter with the squirrel, which ended a few minutes later when the mammal population of the jack pine was reduced by one. Lankinen, who is interested in animals' habits, not their hides, had no such fate in mind for the marten. Once he had taken the photos he wanted, he left the jack pine alone. It was the last tree in its row, and the marten eventually scrambled down from it and chased after the woods—which had retreated a little bit just in the course of the morning.

Photograph by Wayne Lankinen

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Additional Reading

Klipspringers and Monogamy (p. 40)

For a comparative review of the ethology and behavioral ecology of klipspringers and other hoofed mammals of Africa, see W. Leuthold's *African Ungulates* (Berlin: Springer-Verlag, 1977, vol. 8 of the Zoophysiology and Ecology Series). Robin Dunbar discusses the significance of fidelity and long-term pair bonds in "The Ecology of Monogamy" (*New Scientist,* vol. 103, No. 1419, pp. 12–15). When they encounter predators, klipspringer male-female pairs deliver a specialized alarm call in duet. Ronald L. Tilson and Peter M. Norton report on their research on this warning signal in "Alarm Duetting and Pursuit Deterrence in an African Antelope" (*American Naturalist,* vol. 118, pp. 455–62). Tilson explores the animal's methods of dealing with predators in "Klipspringer Social Structure and Predator Avoidance in a Desert Canyon" (*Journal of Madoqua,* vol. 11, pp. 303–14).

Ross's Metalmark (p. 48)

The first description of Ross's metalmark was published in 1964 by Harry K. Clench, who named the butterfly after Gary N. Ross: see "A New Species of Rioginidae from Mexico" (*Journal of Research on the Lepidoptera,* vol. 3, pp. 73–80). Ross wrote the two important articles on the species' life history: "The Ecology and Ethology of *Anatole rossi,* a Myrmecophilous Metalmark (Lepidoptera: Rioginidae)" (*The Annals of the Entomological Society of America,* vol. 59, pp. 985–1004) and "Early Stages of *Anatole rossi,* a New Myrmecophilous Metalmark" (*Journal of Research on the Lepidoptera,* vol. 3, pp. 81–94). H.E. Hinton's "Myrmecophilous Lycaenidae and Other Lepidoptera: A Summary," published in 1951 (*Transactions of the South London Entomological Natural History Society,* 1949–50, pp. 111–75), continues to be the definitive general description of ant-caterpillar relationships. Both W.M. Wheeler's *Ants: Their Structures, Development and Behavior* (New York: Columbia University Press, 1910) and A.B. Klots's *The World of Butterflies and Moths* (London: George G. Harrap and Co., Ltd., 1958) have small but good sections on ant-caterpillar interrelations (see pages 339–60 in Wheeler and 138–42 in Klots). Wheeler's book continues to be the standby in the field, despite its age; Klots's study is also a primary source of reference.

Spanish Village (page 68)

Ruth Behar's *Santa María del Mo* scheduled to appear from Princeton University Press, Princeton, in the spring 1986, is a detailed study of the traditional agricultural life styles of peasant farmers in a small Leonese village. *Neighbors: The Social Contract in a Castilian Ham* (Chicago: University of Chicago Press, 1970), by Susan Tax Freeman, highlights the importance of communal agrarian traditions in the Spanish countryside. For discussion of the recent transformation of Spanish rural life, see Carmelo Lisón Tolosana's *Belmonte de los Caballeros: Anthropology and History in an Aragonese Community* (Princeton: Princeton University Press, 1983); the larger, national picture is provided in Joseph Aceves and William Douglass's *The Changing Face of Rural Spain* (Cambridge: Schenkman, 1976). Susan Harding's *Remaking Ibieca: Rural Life in Aragon under Franco* (Chapel Hill: University of North Carolina Press, 1984) concentrates on the long-term effects of agrarian reform on the life of a Spanish farming population. For a general treatment of the social, economic and cultural life of peasants, see Eric Wolf's *Peasants* (Englewood Cliffs: Prentice-Hall, 1966); for a historical overview see D. B. Grigg's *The Agricultural Systems of the World: An Evolutionary Approach* (London: Cambridge University Press, 1974). Dorothy Hartley's *Lost Country Life* (New York: Pantheon, 1979) reconstructs of the agrarian life cycle in old Europe. Also relevant are M. Redcliff's "The Future of Agriculture in a Spanish Pyrenean Village and the Decline of Communal Institutions" (*Ethnology,* vol. 12, pp. 193–202) and Robert McC. Nutting's "What Alpine Peasants Have in Common: Observations on Communal Tenure in a Swiss Village" (*Human Ecology,* vol. 4, pp. 135–46).

Rita Camp

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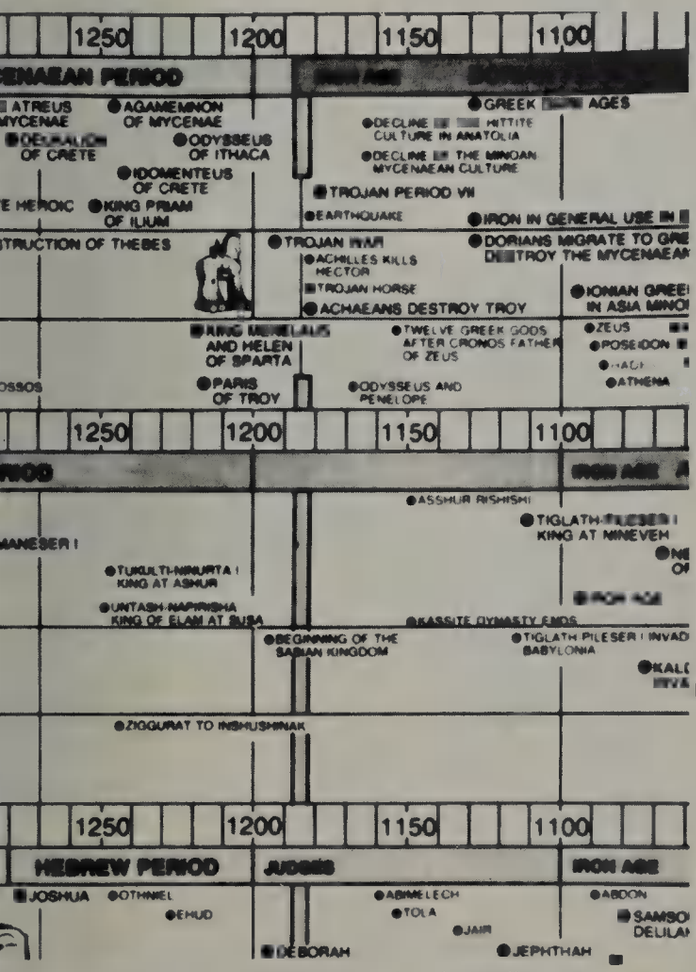

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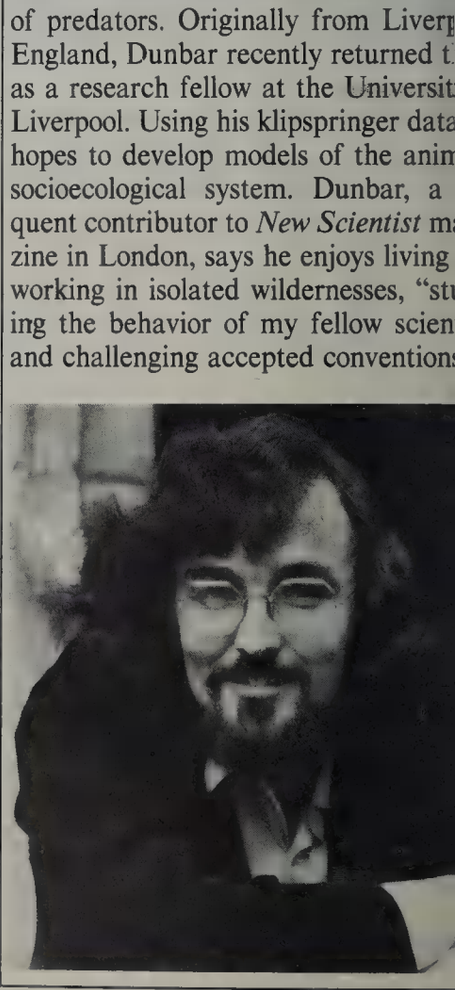
NH-11

Authors

In the summer of 1984, **Ruth Behar** (page 68) returned to the Spanish village where, three years earlier, she had completed fieldwork for her doctorate in anthropology. Behar (left) found that in her absence a land consolidation program had begun to erase community relations and agricultural practices that had survived from medieval times. In her article in this issue, she describes how government engineers did not anticipate all the consequences of altering the ancient pattern of land ownership. Currently a Rockefeller Residence Fellow in the Atlantic Program at The Johns Hopkins University, in 1986 Behar will become an assistant professor of anthropology at the University of Michigan. Her most recent research has been on witchcraft, magic, and male–female relations in colonial and contemporary Mexico. Her future plans include studying a religious revitalization movement in northern Mexico and southern Texas and continuing to document changes taking place in rural Spain.

When he began his graduate work in biology at Louisiana State University in 1962, **Gary N. Ross** (page 48) went on a six-month expedition to investigate butterfly populations in Mexico's relatively unknown Sierra de Tuxtla. Little did he realize that he would discover a new species in the process. This butterfly, named Ross's metalmark in his honor, became the subject of his master's thesis and is the basis of his article in this issue. His doctoral dissertation dealt with all of the region's butterflies. Ross has also done fieldwork elsewhere in Mexico and in Central America. At present, he is studying the natural dyes and biological motifs used in the weavings of the Zapotec Indian culture of Oaxaca, Mexico. Recently he arranged for a major exhibition of these textiles in Baton Rouge, Louisiana, where he is professor of biology at Southern University.

While studying the social biolog gelada baboons in Ethiopia, **Robin Du** (page 40) became interested in the s antelopes darting shyly about his s site. Klipspringers, he learned, were ally paired off, and their fierce fideli each other made him wonder about nogamy. As he reports, the klipspri bond is founded not on love but on the of predators. Originally from Liverp England, Dunbar recently returned t as a research fellow at the Universit Liverpool. Using his klipspringer data hopes to develop models of the anim socioecological system. Dunbar, a quent contributor to *New Scientist* m zine in London, says he enjoys living working in isolated wildernesses, "stu ing the behavior of my fellow scien and challenging accepted convention



Some naturalist-photographers started out as school teachers and later yielded to a stubborn artistic impulse. Others—perhaps those enamored more with the technology of photography—have backgrounds in electronics. But a lumberjack? "I just saw all these nice pictures around," says **Wayne Lankinen** (page 108), who runs his own woodcutting company in Pearson Township, Ontario, Canada, "and I thought I'd give it a try." Apparently it's been a nice try: Lankinen, who lives in the area where he was born and does the work his father did, is selling more and more photographs and feels creasingly involved with his second car He certainly spends enough time in field, five or six days a week, cutting p lar and jack pine into eight-foot-l blocks, which he sells to the local pa company. He does his work on gov ment land designated for logging. "I handle a power saw a lot," Lankinen s "and there's still lots to do. But I'm th ing of doing photography full-tim Lankinen was logging when he ca across the marten featured in this mon "Natural Moment."

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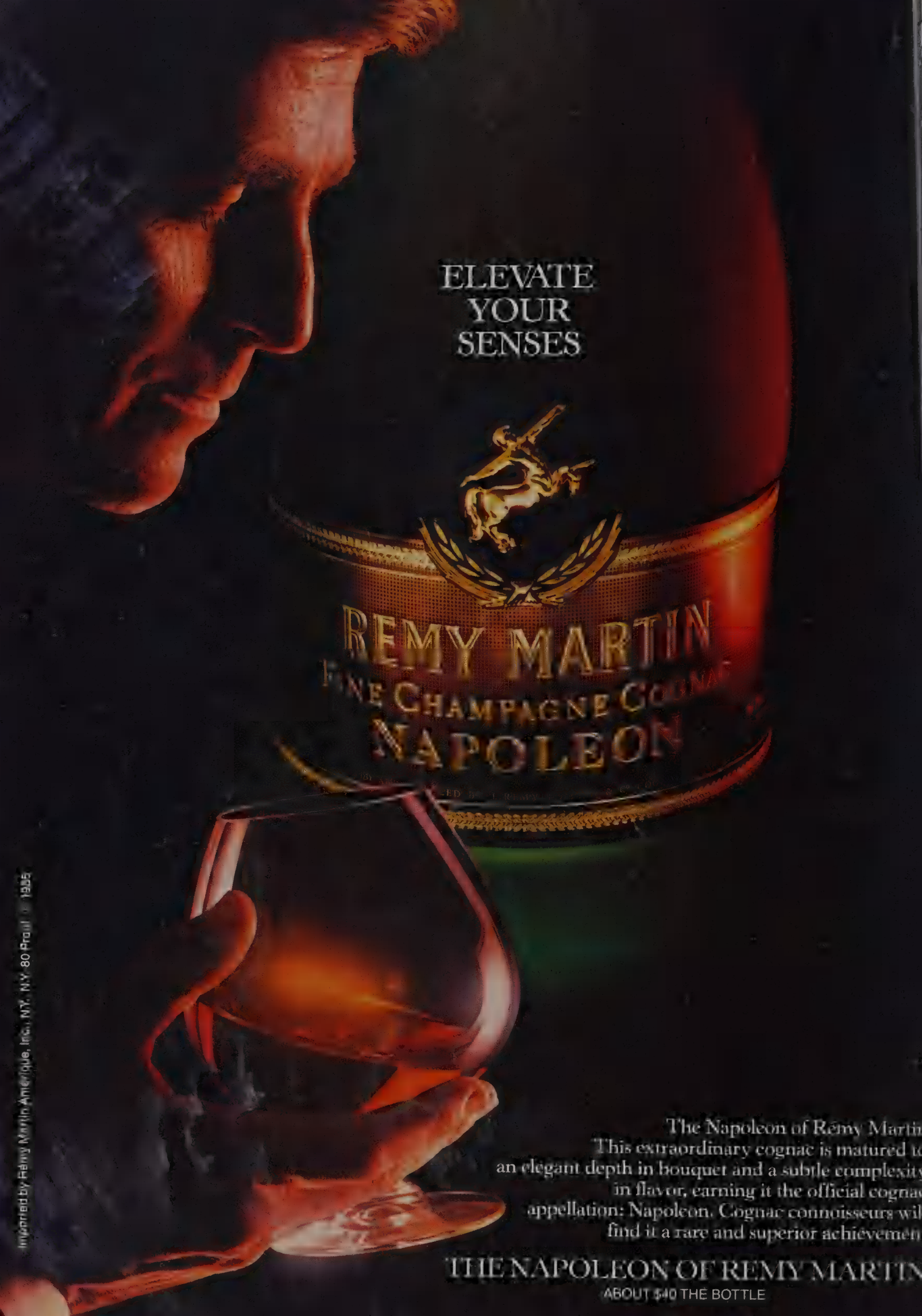
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Letters

Symbiosis Unabashed

As an unabashed enthusiast of the protists (protozoans, algae, and the like), I was disturbed by the introduction to O. Anne Rasa's otherwise interesting article on dwarf mongoose/hornbill mutualism (September 1985). Particularly jarring was the assertion that "mutualistic relationships that cross taxonomic class lines are especially rare." In fact there are few, if any, animals or protists that do not harbor bacterial, viral, and/or protistan symbionts. Examples range from the metabolically vital zooanthellae and zoochlorellae of coral reefs to the darling of molecular biologists—the bacterium *Escherichia coli,* which is part of our normal gut flora.

Nor is symbiosis foreign to either plants or fungi. The roots of most groups of vascular plants rely on their associated mycorrhizae (literally "fungus roots") for the uptake of essential elements like phosphorus. In turn, the fungi receive organic carbon from the associated plant. Of course the finest example of plant/fungal symbioses is the lichens.

Finally, the nineteenth-century proposal that mitochondria and chloroplasts originated as prokaryotic symbionts has many adherents. If mitochondria did originate as symbionts, every cell in our bodies harbors a very ancient symbiont.

LYNN J. ROTHSCHILD
Providence, Rhode Island

Bamboo Shoots

Although I have not been to Japan and have not observed the weekend dancing in Yoyogi Park described by C. Scott Littleton in "Tokyo Rock and Role" (August 1985), I must react to some of the comparisons made with American and specifically southern California youth gangs.

As a correctional educator, I work daily with youths who are members of gangs in East Los Angeles. These gangs are not lacking in organization, show both loyalty to senior members and to group values, and can generally be described as fastidious in their appearance. In these characteristics, they are more analogous to the Wild Drivers and Bamboo Shoots than Mr. Littleton may suppose.

Group loyalty, deference to senior members, a tidy appearance, and an organizational structure are as much a part of American youth gangs as they are characteristics of Wild Drivers and Bamboo Shoots. These cross-cultural comparisons should be noted as clear similarities.

GARY DELANOEYE
Carpinteria, California

Food Chain: Who's on Top?

The solution to the problem of the "Lake Bottom Tyrant" (August 1985) is so obvious, I am surprised that none of the learned men and women who are studying this crawfish problem have come up with it yet.

Since the rusty "crayfish" (as the rest of the country refers to what we know as crawfish) is at the top of the food chain in their Wisconsin lakes, the only logical thing to do is to put man (women and children) at the top of the food chain. This can easily be done by sending several Cajun families from southern Louisiana to Wisconsin: The rusty crawfish population will decrease rapidly. We Cajun know 102 uses for crawfish, about 100 being ways to eat them.

KATHLEEN KILGEN
Cut Off, Louisiana

Street Children

Brian Sutton-Smith's review of *Children of the City*, by David Nasaw (October 1985) did not mention—or failed to list—one lucrative employment of the street children described in the book.

My mother, born 1887, said that one of her most vivid first impressions of life in a big city when her family moved to Philadelphia about 1900 was seeing boys fighting on the street over what they termed doggie diamonds.

She learned that these dog droppings—particularly those with a white color when dry—were sold by the boys to tanners of fine glove leather in the city. And the term doggie diamonds has remained in our family's vocabulary ever since.

Author Sutton-Smith seemed to indicate that shoeshine boys went out of fashion in U.S. cities far earlier than I know they did. My late husband, seventh child of a widowed mother, put himself through high school in the late 1920s by shining shoes and running errands that did not exclude deliveries of contraband hard liquor to prominent citizens, as well as other edge-of-the-law pursuits.

It seems to me that times and necessity make their own mores for all of us.

VERNA FORBES WILSON
Salt Lake City, Utah

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Ambivalence in Toyland

Playthings can both isolate and socialize

by Brian Sutton-Smith

For most of us, toys are what we give children at Christmastime. Sixty percent of all toys (seven billion dollars worth) are sold during this season, and most of the rest are given on birthdays. So whatever they may have stood for in history and whatever they may tell us about human nature, toys are first and foremost Christmas presents.

All our celebrations—not only Christmas but also Thanksgiving, family birthdays, presidents' birthdays, Easter, Valentine's Day, and Halloween—have one thing in common. Originally some of these festivals were religious occasions, and in various quarters, they still are. Others celebrated the change of seasons, and their rituals were concerned with the magic of survival in the face of changes in nature. Still others were celebrations of nationhood. During this century, however, the observation of these holidays has become increasingly centered, not on widely shared cultural or religious values, but on the family.

Holidays usually reflected those parts of society where the pressures and conflicts are felt to be the greatest. Thus, in the past, when class divisions were a great burden on the lower classes, a festival was likely to be a reversal of that class division, as in the traditional Mardi Gras, in which "lowly" people pretended to be kings and queens and often shouted insults at, and even physically injured, those of higher social status. In the current, modified New Orleans festival, people dress up as royalty and toss bounty from their floats, which the crowds scramble for. What they are tossing out may be relatively worthless plastic necklaces masquerading as the crown jewels, but there remains an echo of those social divisions that, though mocked in the festival, have not changed in everyday life.

If festivals usually reveal the major conflicts in any given society, then the modern tendency of turning all festivals into family festivals could lead to the conclusion that the family is an endangered social form. Perhaps we celebrate all these family festivals because we fear that in the modern world, the family is falling apart.

By many standards the family is indeed falling apart. Three hundred years ago it was the center of most work life, most political life, most religious life, any educational life, and most reproductive life. In this century, many of these functions are attended to elsewhere—in factories, political parties, churches, schools, and family planning centers. In addition, modern society prizes individualistic ambition in school and in business. People are rewarded for putting to one side their marriages, children, families, communities, and churches in favor of the public worlds of work and success. But the giving of toys, especially at Christmastime, helps to restore the social bond between parents and children. Toys represent a bulwark against the many forces of modern society, including divorce and ambition, that threaten to tear families apart. Obviously there are many other ways in which modern families hang together, many festivals other than Christmas, and many other kinds of personal and religious dedication that serve the same purpose. But the point here is that toys are one of the contributors; one of the ways that remind family members of the "togetherness" they wish to preserve.

Paradoxically, the family that gives toys at its Christmas celebration of togetherness does not expect to spend any great amount of time with the children on whom they have bestowed these playthings. On the contrary, despite the hoped-for family bond, one of the purposes of toys is to insure that children can occupy themselves without making any great demands on the parents' time. The parent who gets down on the floor to play with a child on Christmas Day is usually doing a most remarkable thing—something seldom repeated during the rest of the year. These are, after all, busy parents committed to their work or their success in the larger society, and they do not have much leftover time in which to play with their children. Success in the modern world is generally a relatively lonely pursuit.

In modern society the rise of the toy as a child's gift can be seen as the rise of a means to accustom children to solitary preoccupation and solitary striving for achievement. One criticism of the modern toy is that it does just that—makes children too solitary and too unsociable. So does television when children watch it alone. An estimated eighty-three million American homes (98 percent) have TV, and children from two to five years of age watch it an average of twenty-eight hours per week. Those from six to eleven watch for an average of twenty six and one-half hours per week. The video game, that computer-based activity in which children spend many hours all by themselves, is only the latest of a whole series of toys and games that have been criticized for making children unsociable. Even girls' dolls and soft toys are as much a modern assuagement for loneliness as they are a training in traditional child care.

In effect the human condition has mimicked the scientific condition. The isolating we have done with atoms, we now do with individuals. The frame of mind that makes the abstractions of science possible is built up by detached and often solitary examination and inspection of the data at hand. We isolate variables in order to carry out experiments, and we isolate our thinking selves in order to be capable of carrying out experiments. We use the same analytical and impersonal processes in industry. With toys, we train childrens' minds and we habituate the children to solitary, impersonal activity. What began with Locke's blocks has been continued

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with puzzles, clay, trains, Erector sets, Tinker Toys, and a hundred plastic simulations advertised on television. The years of play with toys, followed by years of academic study (which has to be done largely with one's own mind going over and over material), are what lead to the expert who has within his or her head banks of information to be called on when needed. Even individuals who work in such social fields as medicine or business must develop themselves as resources, as repositories of information and skill.

There is little mention of toys in the history of play, neither in earlier historical times nor in cross-cultural studies. This is not because there were no playthings. In tribal societies dolls were constructed for little girls and bows and arrows or spears for little boys; children played with mud, twigs, and stones and made facsimile houses and cattle. But, in general, their use of objects was social, a part of teaching by adults or of play with other children. Babies had no toys, although in a few societies female adults and female children played with babies. The nature of play throughout history has been predominantly play with others, not play with toys. Today, even though children nearly always prefer playing with other children to playing on their own, they spend the greater part of their time playing alone. This is even more true of suburban children than of city children. The wealthier the children, the more likely they are to be confined to their houses and a bedroom usually stuffed with all kinds of toys. Often, the child will have no siblings or, at best, only one sibling of a different age, making satisfactory play difficult.

Our culture emphasizes childhood isolation and individuation in many other ways as well. The modern physical approach to the baby is to isolate it as much as possible from the ongoing events of family life and yet, contradictorily, to stimulate it as much as possible in order to increase its intellectual responsiveness. In this way, the general desire for solitariness is united with the desire for achievement, which is thought to require continual and intensive intellectual stimulation. The compromise is to have the stimulation carried out by physical devices that do not require the participation of another person. Every modern manual advocates that the parents themselves should stimulate and play with the child; yet no one advocates the kind of historical closeness we are familiar with, namely, that of tribes where the mother carries the baby constantly on her back, even while she works in the fields, until such time as she hands the task over to the baby's older female sibling. The modern emphasis on interaction has a much more specific focus. It is meant primarily to increase intelligence.

Perhaps it is no accident that the major topic in the scientific study of infant social development has been *attachment*. The issue is how babies become attached to mothers; how, as a result of this attachment, they begin to fear strangers and later to fear that the mother will leave them. They usually begin to demonstrate a clear preference for the main caretaker over others by about the age of five months. At about nine months they show some anxiety in the presence of strangers, and at about thirteen months, if the mother leaves them, they show some separation anxiety.

While very few psychologists have considered it instinctive, attachment has nevertheless remained the primary topic in the science of infant social development. Again, this is enlightening because the thrust of modern society has been toward detachment and alienation, rather than toward attachment and closeness. The growth of the city-state, beginning some 5,000 years ago, has led to a cumulative detachment of its members from their roots in village, religion, ethnicity, and, finally, the family.

Various modern mechanisms in the ecology of infancy serve both to isolate the modern baby (the bedroom, crib, playpen, infant seat, walker, wind-up swing, and jump seat) and to increase its stimulation through physical objects (wallpaper, pictures, plants, and toys). We can get a better sense of how recent all these objects are in a child's life if we realize that objects in the parents' lives are also fairly recent. From the time of ancient Egypt until about A.D. 1500, it was not typical for even the homes of the wealthy to be furnished. People sat and slept on sacks of grain or mounds of straw. The wealthy had little besides a trestle table. In Moslem culture, a couch, a divan, or an ottoman was the symbol of the ruler and his court. When asked what they value most in their homes, modern parents more often than not indicate the furniture, and they often suggest that these objects are symbols of their personal accomplishment.

It was not, however, until this century that children began to inherit this state of affairs and to have privacy from the moment of birth. Furthermore, infants having their own bedrooms is largely a twentieth-century phenomenon, a final stage in the evolution of privacy since medieval days when everyone slept in the same room or those days when upper-class children slept with the servants. Some researchers believe that it was in the last

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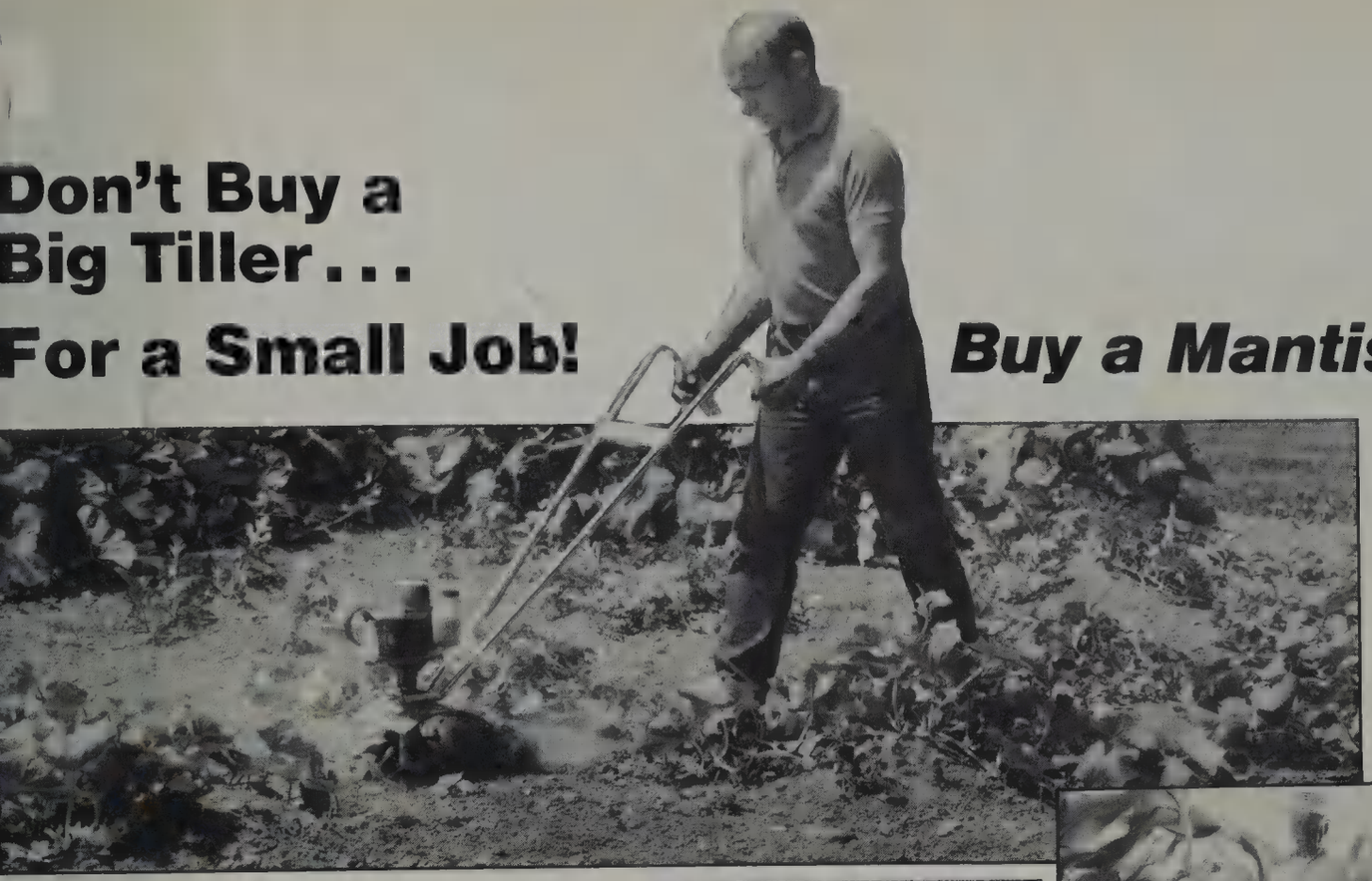

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half of the eighteenth century that children in England first came to be regarded as consumers and agents for the ambition of middle-class parents. This was the time when books were first written specifically for children, using large print and simple language. It was also the time when toys became industrialized, when toy shows traveled around like circuses, and when toy shops were established in major cities. By 1800 some children were being dressed for the first time specifically in children's clothes. And most of the children of middle-class parents were being sent to elementary schools whose major function was to prepare the pupils for the new commercial (boys) and social (girls) opportunities of the Industrial Revolution. Even some working-class parents appear to have sought access to reading for their children and in some cases access to schools.

The modern child's bedroom is typically a place for both privacy and stimulation. Some experts think the rooms should be light and have fanciful wallpaper. One study has shown that parents tend to put animals on the walls of boys' bedrooms and floral decorations on those of girls. A dimmer switch, which allows modification of light at bedtime, or a night light saves the room from complete darkness.

Based on the view that babies enjoy novelty and like to explore their worlds visually, experts suggest that the crib be placed so that the child can look out a window, see colored pieces of glass or mobiles turning outside in a slight breeze, or perhaps see a bird feeder behind plants growing on the window sill. Small lamps hanging upside down may cast light spots on the ceiling. Wind chimes hanging near an air conditioner can make interesting sounds, and a radio going quietly in the background adds to the room's soothing effect. An industry has grown up around the development of the infant's bedroom and crib, but this probably has more to do with the culture's statement about itself than about its knowledge of the effects on the baby. Perhaps a baby in a more stimulating environment will become a livelier adult than otherwise, but that is by no means certain. More likely, the infant's bedroom and crib are a statement about the parents as well as an influence on their children. Parents decorate and furnish their homes to reflect those styles of architecture or painting they are particularly fond of or feel are fashionable. In this way they satisfy their interests and prove their worth to themselves and their friends. Similarly, infant bedrooms may demonstrate a parental concern for children and a belief in their early educability. They are the most recent reflection of parental ambition for the achievement of their young, which first became noticeable about 200 years ago.

Here again, we have the paradox that this frame of conventional niceness—animals or flowers on the walls and the moving mobiles over the cribs—is taking place in the one spot where, over the years, children can harbor whatever private wishes they choose, whatever fancies, whatever rebellions, whatever earthly concerns. In this solitary haven, embodying the parents' first vote for tranquillity, the child's future behavior, sane or monstrous, is incubated.

In time the child graduates from a crib to a playpen, which can be slept and played in, moved to the backyard, or put in the living room. It is decorated and filled with toys, and the baby may learn to walk by hanging on to the railing around the playpen's sides.

Experts recommend that parents put the playpen in a room other than the one they are working in because if the baby can see the parents, it will want to play with them rather than by itself. Left alone in another room, however, the baby will presumably play happily by itself for a long period of time. Still, parents are advised not to leave the child alone too long lest the playpen resemble a prison.

We justify the devices we use to isolate children by pointing out the relative danger of the modern home—with its electrical light sockets, dog dishes, cat litter, lamp cords, low coffee tables, small objects on the floor (pins, pennies, buttons, paper clips, screws, matches), television-set knobs, ashtrays, cigarette lighters, tablecloths, radiators, wastebaskets (containing razor blades and spoiled food), plastic bags, stairs, plants, and bottom cupboards filled with soaps, cleansers, and poisons. This array makes it feasible to argue that we isolate the baby for its own safety, not because isolation is an endemic characteristic of modern society; that isolating the baby shows our common sense, not our common character.

The physical seclusion of the child is also consistent with the use of toys to isolate the learning processes. This supports the thesis that an essential function of modern child rearing is to turn children into adults capable of functioning by themselves.

Although not many studies tell us just how children spend their time after infancy, at least one study, which focused on children in small nuclear families, found that in the second year of life children spend as much as 80 percent of their time by themselves. That involves exploring, accomplishing mastery, doing nothi much, eating, passing time, preparing f activity, and going to get things.

Children with siblings or peers in t neighborhood are, of course, more lik to convert play with toys into some form social play. Accordingly, we would expe that when they go to nursery school, whic places great emphasis on learning to c operate and to share, children would e gage in group play. But experiments sho that when toys are present, young childre are less likely to play with other childre and more likely to focus on the toys. Whe they are left with other children but wit out toys, they are more likely to play wit the other children than to play alone. Toy therefore seem to decrease the sociabilit of play. Nevertheless, new toys also, i time, make a contribution to new forms o social play. Earlier studies of playground also showed that if children had play ground apparatus, they played in a mor solitary way and with less aggression; bu if they had no playground apparatus the played together more often but with mor aggression.

Throughout the educational and thera peutic communities there is a perennia need to "socialize" children and to expec that those who do cooperate with other are in better developmental shape. Thi has led to the unnecessary contrasting o solitary and social play, whereas, in fact the healthy child is capable of both. True disturbed or maladjusted children ofte have enormous difficulties in social play but their problems should hardly be used to judge the functions of play among un disturbed children. Nor should these "spe cial" children be used to obscure the his torical drift toward isolation in the play o children with toys. We began with the par adox that parents use toys not only for the purpose of bonding but also, contradicto rily, for the purpose of shaping their chil dren into solitary self-sufficient individ uals; now, however, we find that once children are in school, their teachers and therapists try to resolve this paradox by emphasizing the cooperative purposes o play with toys. When parents implicitly say to their children, "We give you these toys in order to bond you to us, now go and play with them by yourselves," they are conveying to them an important message about civilization. That message may be subsequently undermined by therapists and educators who must deal with the less fortunate outcomes of our "civilized" loneliness.

Brian Sutton-Smith, is a professor of education and folklore at the University of Pennsylvania.

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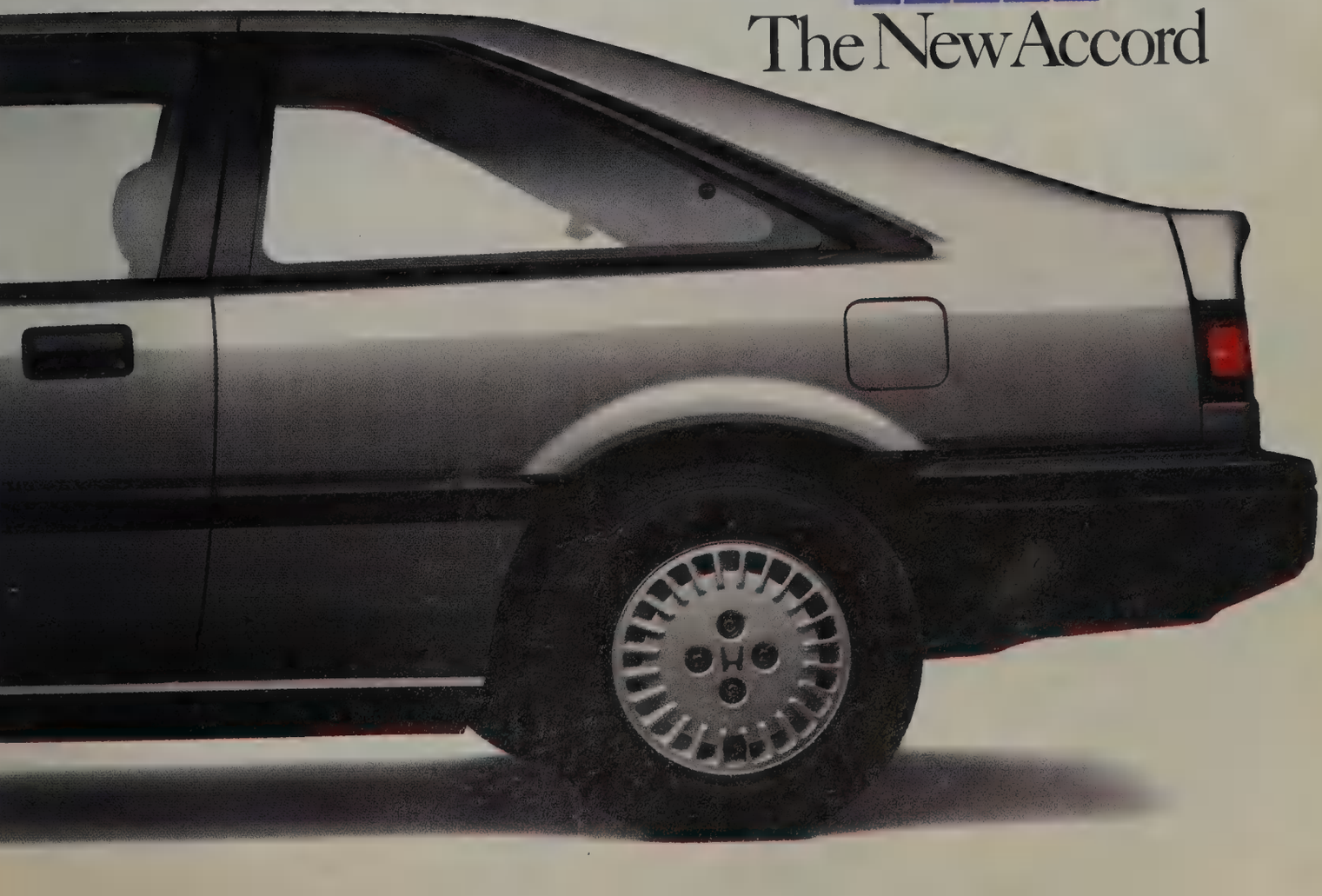

The Babylonians Saw That Comet, Too

Clay tablets show that the comet was noted nearly two millennia before Halley

by F. Richard Stephenson

While space scientists have been preparing for the forthcoming return of Halley's comet to the inner solar system after a lapse of seventy-six years, other researchers have been investigating ancient records of the comet's visits. The most remarkable achievement has been the discovery of observations from both 164 and 87 B.C. recorded on Babylonian clay tablets that are now in the British Museum in London. These are the earliest reliable accounts of the comet from any part of the world. Apart from their historical interest, the observations have enabled astronomers to test current theories regarding the comet's orbital motion.

Until about a century ago, very little was known about the great astronomical tradition of Babylon. However, the famous astronomer of Alexandria, Claudius Ptolemy—author of the *Almagest*—hinted at the true scale of observational astronomy as practiced in Babylon. Writing about a century after the time of Christ, he stated that he had access to astronomical observations from Babylon going back to the reign of King Nabonassar (747 B.C.).

Practically all our knowledge of Babylonian astronomy has come as the result of the discovery of ancient Babylonian texts. Somewhat surprisingly, very few of these texts were purposely excavated. Instead, they came to the notice of the scientific community in a haphazard way. During the eighteenth century, European travelers remarked on the pillaging of the vast ruins of what had been Babylon by gangs of laborers from nearby villages. This large-scale vandalism continued throughout much of the nineteenth century as building after building was demolished in order to remove their fine baked bricks for reuse in new construction. In the 1870s, however, large numbers of broken clay tablets bearing inscriptions began to reach antique dealers in Baghdad. These had evidently been dug up accidentally at the site of Babylon, and somehow their value as curios had been recognized. Almost all of the available material, numbering some 10,000 tablets, was bought by the British Museum through London dealers between 1876 and 1882. Then the supply ceased.

In the late nineteenth century, Assyriologists who were studying the Babylonian tablets in the British Museum, and could read the cuneiform in which they were written, recognized that a number of the tablets were concerned with astronomy. In the last two decades of the nineteenth century, researchers spent many years laboriously copying the Babylonian texts by hand; they also joined hundreds of broken tablet fragments. More than a thousand tablets devoted to astronomy were copied. Regrettably, most of these drawings were placed in the museum archives and remained forgotten until the early 1950s. We now know that several tablets referring to Comet Halley were among them.

After Edmond Halley in the early 1700s recognized the periodicity of the comet that now bears his name, historians and astronomers found records of its visits dating as early as 12 B.C. Before the European Renaissance, Chinese dynastic histories were the main source of observations; until recently, however, the investigation of possible sightings before 12 B.C. drew a virtual blank. The expected dates of the three previous appearances, based on modern calculations, are 240, 164, and 87 B.C. Ancient Greek and Roman writers mention several comets, but the dates are very vague. These difficulties led me to initiate a search of the Babylonian astronomical texts in the British Museum. Among ancient civilizations, only the Babylonians practiced stargazing as enthusiastically as the Chinese, but the study of their observations has been very limited.

The Babylonian texts were written in a cuneiform script on clay tablets. This type of writing, prevalent in the ancient Nea East, was produced by pressing a reed st lus into clay to form a series of triangula wedges. The clay was then sun-dried baked in ovens. Cuneiform writing wa first introduced by the Sumerians, and th earliest known documents date fro about 3100 B.C. The choice of materia was probably dictated by availabilit both clay and reeds are very common southern Iraq where the Sumerian civ lization flourished.

The texts have been classified into fou distinct groups: diaries, "goal year texts excerpts, and almanacs. Babylonia sightings of comets are noted only in th diaries, which are day-to-day summarie made by astronomers.

The diaries all originate from what known as the Late Babylonian period. Th earliest datable fragment comes from th year 652 B.C. and the next most recen from 568 B.C. (in the reign of King Nebu chadnezzar, during the exile of the Israe ites in Babylon). Most of the surviving dia ries come from between 380 and 60 B.C However, it seems likely that they orig nally covered the entire interval from 74 B.C. (as attested by Ptolemy) to at leas A.D. 75. In his *Almagest*, Ptolemy cite three Babylonian reports of eclipses fro years corresponding to 721 and 720 B.C Although there are no extant diaries fro this early period, tablets containin records of lunar eclipses, which the Bab ylonians excerpted from their own diarie go back at least as far as 702 B.C. Hardl any diaries are extant before about 38 B.C. or after about 60 B.C., but the reason not known.

From the diaries it is possible to recon struct a detailed picture of the kind of ob servations the Babylonian astronomer were making. A typical Late Babylonia diary contains astronomical observation for half a year. The Babylonians bega each month with the first visibility of th young crescent moon in the western sk

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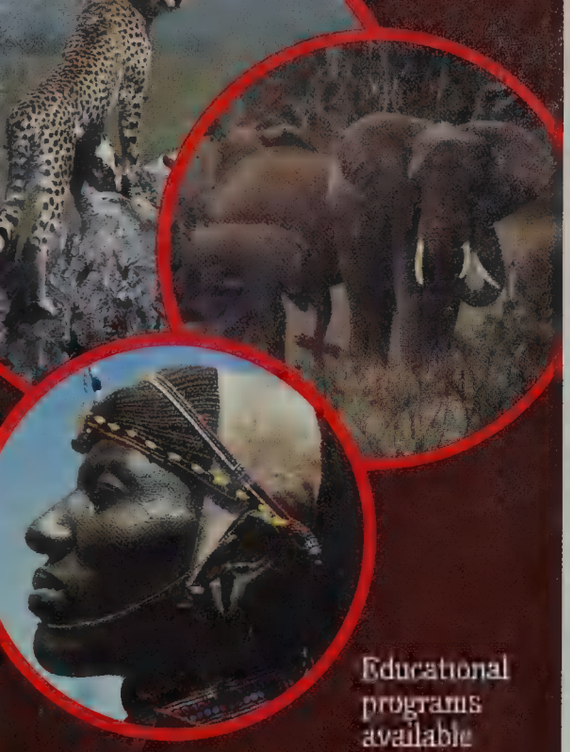

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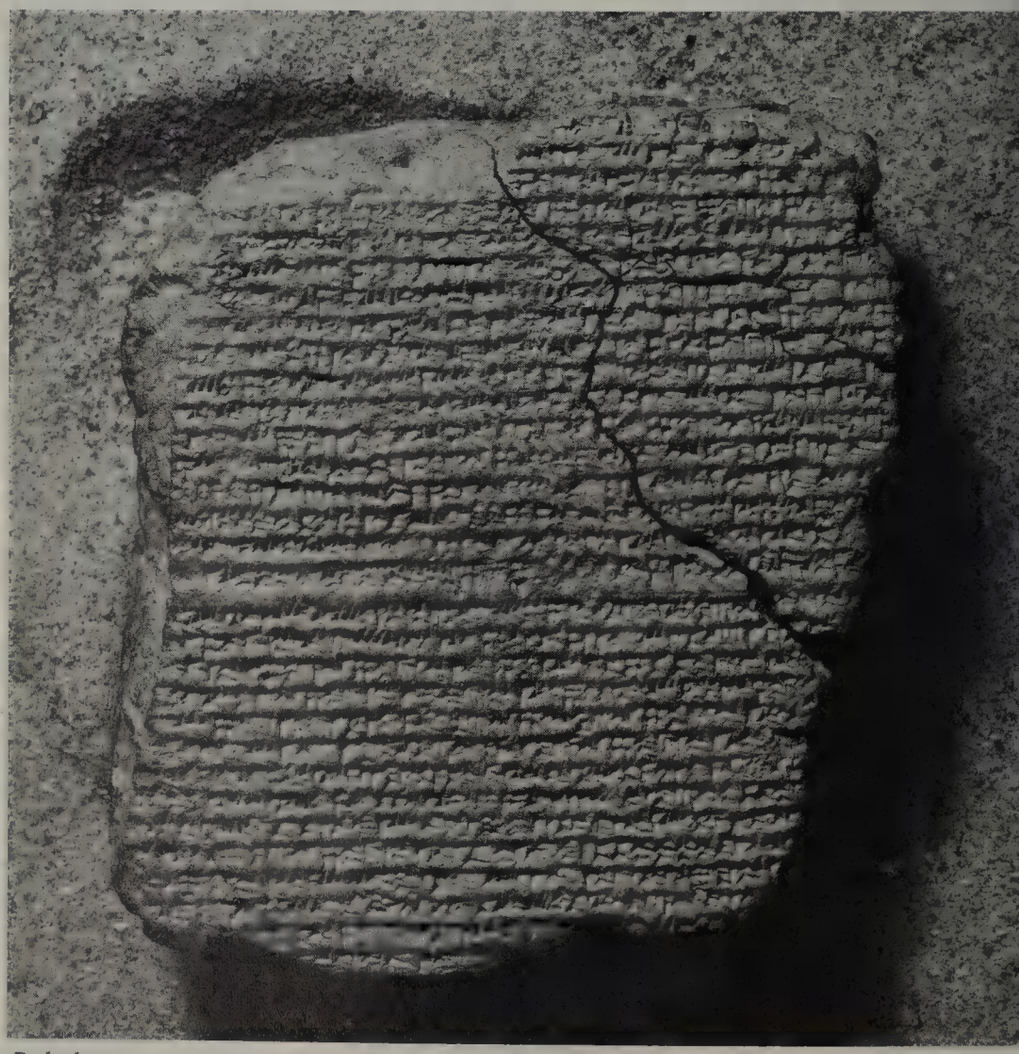
some twenty-four hours after new moon. Their day therefore began in the evening rather than at midnight. The search for the crescent moon closely resembles the observations made today in Islamic countries at the beginning and end of the month of Ramadan. The Babylonian month had either twenty-nine or thirty days, depending on whether or not the crescent moon was sighted at the close of the twenty-ninth day.

Night after night in each month, the conjunctions of the moon with the five bright planets (Mercury, Venus, Mars, Jupiter, and Saturn), as well as with thirty-one selected bright stars, were noted. These stars all lie in the zodiac, the apparent path of the sun, moon, and planets through the sky. The angular distance between the moon and each of these planets and stars was estimated in cubits and fingers, a cubit corresponding to an angle of about 2 or 2.5 degrees and a finger to one twenty-fourth of this amount. Other observations that involved the moon were of eclipses—both solar and lunar—and of the time interval between the rising and setting of the sun and moon at the beginning, middle, and end of the month. Eclipses were carefully observed, and both times and magnitudes were estimated. The most accurate account of a t tal eclipse from the ancient world is fro Babylon and was translated as follows:

Daytime of the 29th [of month Addaru II the year 175 of the Seleucid era], 24 *uš* [unit of time representing the interval for th sky to apparently turn through one degree and hence four minutes] after sunrise, a so lar eclipse began on the southwest sid . . . Venus, Mercury, and the normal star were visible. Jupiter and Mars, which were in their period of disappearance were vis ible in that eclipse . . . [the shadow] moved from southwest to northeast. [Time interva of] 35 *uš* for obscuration and clearing up.

The recorded date corresponds to 13 B.C. April 15, on which day modern cal culations indicate a total solar eclipse wa visible in Babylon. Both Jupiter and Mar were very close to the sun, as the record implies. The estimates of 96 minutes afte sunrise at the start and 140 minutes dura tion agree well with the calculated values The tablet text is badly broken, but thi account forms only a small part of the var ious kinds of astronomical information re corded on a small fragment of clay only about two square inches. Many careful ob servations of lunar eclipses have also sur vived. These data are of great value in cur rent studies of long-term changes in th



Babylonian stargazers noted Halley's comet in this 164 B.C. cuneiform diary.

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earth's rate of rotation due to tides and other causes.

For the planets, the diaries give the dates of first and last visibility, stationary points, and conjunctions with the above-mentioned thirty-one reference stars. Some of this information is calculated rather than observed. Other calculated information relates to the dates of the spring and autumn equinoxes and summer and winter solstices, as well as to the rising and setting of the bright star Sirius.

On each day we also find a brief weather report for both the daylight and nighttime hours. This details instances of clouds, rain, hail, thunder, lightning, rainbows, halos, and even wind direction. Curiously enough, fine weather is never mentioned; it can only be inferred from the lack of information to the contrary.

At the end of each month's day-to-day entries, there is a monthly summary. Based on calculation rather than observation, this summary lists the various signs of the zodiac in which the planets were situated. The Babylonians were the first to divide the zodiac belt into twelve signs, probably about 450 B.C. These names may be translated as: the Hired Man (corresponding to Aries), the Bull of Heaven (Taurus), the Great Twins (Gemini), the Crab (Cancer), the Lion (Leo), the Barley Stalk (Virgo), the Balance (Libra), the Scorpion (Scorpio), Pabilsag—a god—(Sagittarius), the Goatfish (Capricorn), the Giant (Aquarius), and the Tails (Pisces). It is evident that our modern Latin names, derived from the star catalog in Ptolemy's *Almagest,* are mostly direct translations of the Babylonian names, via the Greek of Ptolemy, with certain obvious exceptions.

The monthly summaries also provide information on the fluctuating amounts of six important commodities—barley, pepper, dates, cress, sesame, and wool—which could be bought for one shekel of silver. If prices changed during the course of a month, this was also indicated. Other details reported included changes in the level of the Euphrates River at Babylon—obviously with the risk of flooding in mind—and major local and national events. A particularly interesting piece of historical information is a notice of the death of Alexander the Great (who died at Babylon). The diaries allow us to date this event precisely as June 13 in 323 B.C. (Julian calendar).

Despite the irregular movements of comets, Babylonian records show that they were carefully observed. Descriptions of comets are found in the day-to-day entries in the diaries. That the objects termed *sallummu* by the Babylonians may be reliably identified as comets clear from the various observations. The indicate that the motions of *sallumm* were followed for many days, and not i frequently the direction in which the t (*mishu*) was pointing is specified. Furth support for a cometary interpretatio comes from the Chinese records. The can be little doubt that *sallummu* r ported in 157 and 138 B.C. are identic with comets that were independent sighted in China and described as "bush stars."

Judging from the preserved record damaged though they are, the Babyloni astronomers specifically noted the dat of first and last sighting of a comet and t constellations in which it appeared a disappeared. If a comet was temporari lost to view because of conjunction wi the sun, the dates of setting and risi were noted, together with the appropria constellations. The Babylonians do n seem to have intended to give a comple account of a comet's motion through t sky, as was the policy of Chinese astron mers in later centuries. The earliest me tion of a comet in the Babylonian diari was in 234 B.C., but after this date the are eight further known observatio down to 87 B.C. The years 234 and 87 B represent the earliest and latest datab records of comets in any cuneifor source. This obviously represents a rath narrow range of time. However, in probability comets attracted just as mu interest in Babylon during earlier cent ries even though the records are now lo

Two separate Babylonian tablets copies of the same diary but with slight different readings—contain overlappi descriptions of a comet in the autumn 164 B.C. The first of these accounts may translated as follows: "... the com which had previously been seen in the ea in the path of Anu in the area of Pleiad and Taurus, to the west... [brea ... and passed along in the path of Ea.

The other text, from a much more da aged fragment, begins almost where t previous record ends: "... in the path Ea in the area of Sagittarius, 1 cubit front of Jupiter and 3 cubits high towa the north."

As can be seen, the surviving portion the second text does not mention the wo *comet*. However, the use of the term Ea sufficient evidence. The Babyloni astronomers divided the sky into thr zones named after gods: Enlil, Anu, a Ea. Of these, Enlil was the northern sk Anu the equatorial region, and Ea t southern sky. These terms were nev used in describing the motion of plane but they were regularly used when com

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were referred to (for example, in 210, 120, and 110 B.C.).

It is important to point out that neither of the tablets under discussion carries a date—not the year or the month. This information has been broken away and must be derived by calculations based on the lunar and planetary observations found in the same diaries. In each case, one side of the tablet contains records for parts of two consecutive lunar months, while the reverse side gives details for two further successive months. Both of the cometary accounts are found in the summary at the end of the first side. A date for each tablet of 164 B.C. had been deduced by calculating the planetary phenomena. It became essential for me to verify that date and to make sure that the *same* comet was referred to in both diaries; otherwise, the whole argument would have collapsed.

The key observation proved to be a lunar eclipse that was described on the reverse of both tablets. This was brought to my attention by the keeper in charge of the Babylonian texts at the British Museum, who—along with my student, Kevin Yau—contributed greatly to this investigation. Fortunately, a record of the same eclipse, duplicating most of the details, was also found on a goal-year text. This record gives the precise year of observation (148 of the Selucid era, corresponding to 164–3 B.C.). Other data in the two diaries, such as the constellations in which the planets were found and conjunctions of both the moon and Venus with stars, enabled me to derive a unique date for both cometary records: the lunar month beginning on October 21 (Julian calendar) in 164 B.C. Equally important, several of the lunar and planetary observations in each diary were identical, proving that the tablets are essentially copies of one another. Hence it is evident that the two references to the comet are part of one and the same description.

The composite record of the comet of 164 B.C. agrees extremely well with the calculated motion based on orbital theories. According to those calculations, Halley's comet should have been first sighted between the Pleiades and Aldebaran (the principal star of Taurus) toward the end of September, and about a month later it should have passed about seven degrees (roughly three cubits) to the north of Jupiter, then in Sagittarius. The comet would then be approaching conjunction with the sun and would soon be lost in the evening twilight. The agreement with observation is thus excellent, and there can be no doubt regarding the identity of the comet as Halley's. The rather precise location, "1 cubit in front of [that is, to the west of] and 3 cubits high toward the north" ma well represent the position at last visibilit This would fit in with the characteristi style of Babylonian cometary record which are mainly concerned with first an last sightings.

For 87 B.C., we found only a single brie record of a comet on a small fragment of tablet. The text may be translated as fo lows: "... on the 13th, the interval be tween moonrise and sunset was measure as 8 *uš*. In the first part of the night comet ... [break] ... which in month I day beyond day one cubit ... [break ... between north and west its tail 4 cubi ...."

Once again, neither year nor month preserved. However, there are severa valuable lunar and planetary observa tions, including an eclipse. A starting ep och is provided by the mention of Selet cia, a city that was not founded until 27 B.C. Investigation of the astronomical dat makes possible the derivation of a uniqu date for the diary entry—August 24 in 8 B.C. The lunar month can be readily show to be the fifth of the appropriate year fo the scheme of intercalation adopted b the Babylonians to keep their calendar i step with the seasons. The survivin record of the comet seems to relate almo entirely to the previous month IV (July 1 to August 11), but this is the customar pattern. For much of month IV, Halley comet should have been moving at ap proximately "1 cubit" daily, while its ta would have pointed roughly northwest. B August 24, the day of the diary entry, th comet would have been difficult to discer in the evening twilight. Despite the loss much valuable information, there enough evidence here to identify Com Halley with confidence.

All three Babylonian accounts of Ha ley's comet are of considerable historic interest, since they allow us to extend th record of the comet by two additional r turns—87 B.C. and 164 B.C. These sam reports are also valuable in the study the comet's orbital motion. Despite the apparent crudity, the observations enab us to date the perihelion passage (close approach to the sun) in ancient times mo accurately than modern computations w permit. It is my hope that the missing Ba ylonian observations from even earlier vi its of this most famous of all comets ma yet come to light.

F. Richard Stephenson is an astronom and senior research fellow in the Depar ment of Physics at the University of Du ham in England. His research is centere on historical astronomical records th have value for present-day astronomy.

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Treasures in a Taxonomic Wastebasket

As scientists restudy the Burgess Shale fossils, life in the Cambrian gets curiouser and curiouser

by Stephen Jay Gould

I shall begin by playing a little John Fowles (of *The French Lieutenant's Woman*) in reverse—and why not, since the hero of that novel may be literature's most famous paleontologist. Fowles's book has two endings; this essay has two introductions.

INTRODUCTION 1: In the *Canadian Alpine Journal* for 1908, Charles Doolittle Walcott, paleontologist and secretary (their name for boss) of the Smithsonian Institution, described the appropriate technology for collecting from the great *Ogygopsis* fossil bed of British Columbia:

> The best way to make a collection from the "fossil bed" is to ride up the trail on a pony to about 2,000 feet above the railroad, collect specimens, securely wrap them in paper, place them in a bag, tie the bag to the saddle, and lead the pony down the mountain. A fine lot can be secured in a long day's trip, 6:00 A.M. to 6:00 P.M.

Walcott's ineluctable choice of horsepower led directly to his accidental discovery, the following year, of the most famous and important of all fossil localities (see following article, page 34). I have read two versions of the story. Both agree that the great moment occurred on the final day of the 1909 field season, as Walcott and party led their horses down the slope toward the railroad for the last time. Snow and night had both begun to fall. In one version (the more romantic), Mrs. Walcott's horse slides going downslope and turns up the celebrated slab—the one last rock that Walcott must then examine. In the other version, the slab lies in the middle of the path, blocking their way—and Walcott must dismount to push it aside. In either case, he looks as he pushes (the trademark of any good geologist), and he finds the rarest and most precious of all paleontological gifts—exquisite preservation with soft parts intact. (Any recovery of soft parts is sufficient cause for hosannas in itself, but this fauna inhabited the oldest rocks of our fossil record as understood in Walcott's day—the Cambrian period.)

Walcott bided his time anxiously, returned the next summer, and traced the errant block to its source—a shale lentil above the *Ogygopsis* bed and seven to eight feet thick. He excavated the entire lentil—now called the Burgess Shale—during the next two seasons, as a family affair before the days of "big" science. Walcott wrote:

> Accompanied by my two sons, Sidney and Stuart . . . we finally located the fossil-bearing band. After that, for 30 days we quarried the shale, slid it down the mountain side in blocks to a trail, and transported it to camp on pack horses, where, assisted by Mrs. Walcott, the shale was split, trimmed and packed, and then taken down to the railway station at Field, 3,000 feet below.

INTRODUCTION 2: My office occupies the oldest wing of Harvard's Museum of Comparative Zoology. When we washed the walls in preparation for the first paint job in anyone's memory, we uncovered, in swirling Victorian calligraphy, a taxonomic dictionary of the 1870s. I discovered that I inhabit the former focus and entering exhibit of Louis Agassiz's original museum. (I was doubly delighted because we then didn't have to cover the walls in sparkling white and disrupt my life as only painters can.) The headline to each section reads: "Synopsis of the Animal Kingdom," and the order progresses, by the conventional chain of being, from "Sponges and Protozoa" just under my desk all the way to "Mammals" on the wall. Evidently, this room housed the e ome and key to the entire collection— short take on God's arrangement Agassiz's view) of organisms.

I chuckled when I read the connect link between "lower" (sponges and cora and "higher" (lobsters and clams) inve brates. The label read, simply, "Verme or worms. I laughed because I recogni this name as the old cop-out or garb bag for a major problem of invertebr taxonomy. Some phyla are large, distin and well bounded; we can usually plac coral, a sponge, a bug, or a snail with difficulty. But invertebrate life include wide and frustratingly diverse array soft-bodied, elongated, bilaterally sy metrical animals with sensory organs a mouths up front. We know that, coll tively, they represent a genealogi hodgepodge as wide as invertebrate life self.

Animals sharing this basic architect may have no closer affinity than a bee and a squid. We now have many names them—chaetognaths, gnathostomuli priapulids, kinorhynchs, and so forth but we still don't know their relationsh Our predecessors, following a tradit dating to Linnaeus himself, tended dump them all together into an incho group called Vermes—and I had disc ered an example of this ancient pract on my own wall. The older taxonom knew that Vermes housed an array of ferent creatures, united by an anatomi plan so basic and generalized that it mi evolve again and again in unrelated for They knew, in short, that Vermes was unnatural assemblage—a taxonor wastebasket for the invertebrates that one understood.

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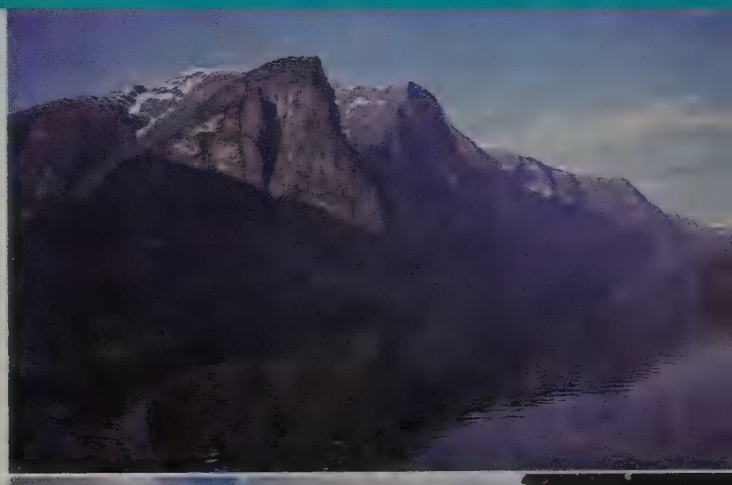

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The conjunction of these disparate introductions is quite simple. Walcott found an array of unique, soft-bodied animals in the Burgess Shale—bilaterally symmetrical creatures of anatomical designs found nowhere else among living or fossil organisms. This discovery defines the greatest interest, and transcendant importance, of the Burgess for our understanding of evolution and the history of life. But Walcott never appreciated what he had found. He followed the usual road and buried his new world in taxonomic convention. He managed to shoehorn every Burgess animal into a modern taxonomic group, and he placed all the real oddballs among the worms. This fateful decision delayed a proper appreciation of the Burgess Shale for more than fifty years. Most well-informed scientists still don't know what treasures the Burgess really contains. We are only now beginning to see properly and to ponder the cascading implications—an exercise so broad that it must occupy this and my next two columns and still only scratch the surface.

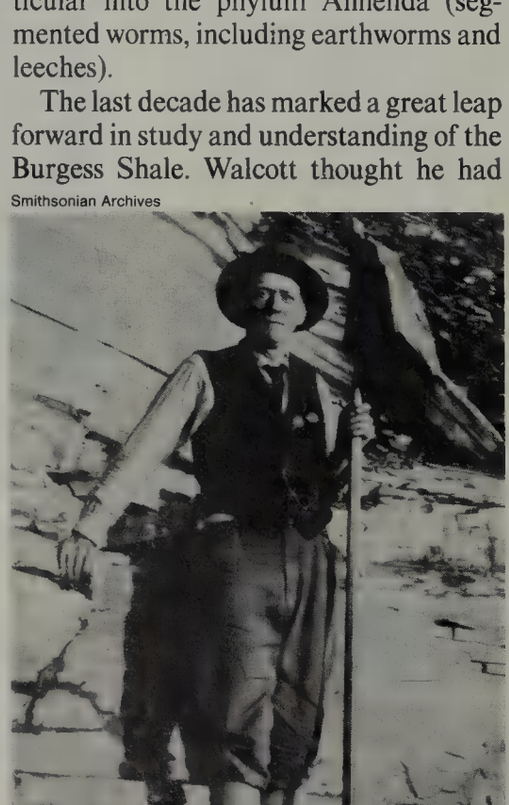
The unusual setting of the Burgess Shale explains why it has preserved the remains of soft-bodied creatures. A massive algal reef, represented today as dolomites of the Cathedral Formation, towered above deep and quiet bottom waters during Middle Cambrian times near the edge of a sea that became part of British Columbia. These deep and stagnant waters were depleted of oxygen (and therefore devoid of complex life), presumably as a result of poor or nonexistent circulation. But mud banks accumulated at the edge of the stagnant basin, adjoining the projecting reef. Here, in well-oxygenated, shallower waters, the varied fauna of the Burgess thrived. Every once in a while, perhaps as a consequence of small earthquakes or other tectonic movements, perhaps simply as a result of sediments accumulating beyond their own point of stability, these muddy banks foundered and slid into the adjoining stagnant basin—a so-called turbidity flow in geological parlance. Suddenly buried in a quiet and stagnant basin devoid of organisms that could eat their remains or even cause them to decay, the soft-bodied creatures of the Burgess mud bank entered a tomb that has endured for some 530 million years.

From the time he discovered the Burgess Shale until after his death in 1927 (in several posthumous papers), Walcott described most of the Burgess animals in a long series of articles for the *Smithsonian Miscellaneous Collections*. This set of papers represents the most anomalous match I know between attention and significance in science—for Walcott's descriptions are the merest thumbnail sketches (he did have other things to do as boss of the world's largest museum), while the Burgess animals are the world's most important fossils. (Our inordinate interest in Lucy and her ilk is only parochial concern, however appropriate, for one little twig of the evolutionary tree—while the Burgess animals represent all we have of several main trunks.)

The reasons for this curious lack of attention are many and varied (including the sociology of territory among paleontologists), but one intellectual factor stands out. Walcott simply didn't recognize what he had—and others, therefore, never sensed the richness. For him, the Burgess fossils were beautiful and unusual in their preservation, but not unique in their biology. Walcott simply placed them in modern groups. I could find not the slightest flicker of a doubt, not a hint of any possible alternative, throughout his papers. (I shall devote next month's column to the reasons for Walcott's decision and to the interesting fallacy underlying it.) In his greatest single burial of uniqueness within conventional taxonomy, Walcott put almost every bizarre Burgess organism into the traditional wastebucket, Vermes (*Smithsonian Miscellaneous Collections*, vol. 57, 1911, p. 109), in particular into the phylum Annelida (segmented worms, including earthworms and leeches).

The last decade has marked a great leap forward in study and understanding of the Burgess Shale. Walcott thought he had

Smithsonian Archives



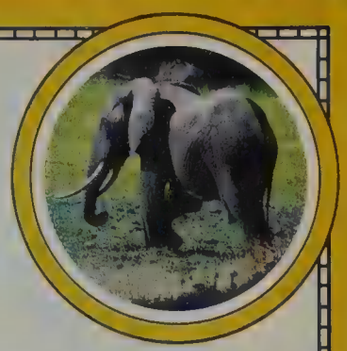
Walcott at Burgess Shale

cleaned out the original lentil—so m
scientists didn't pursue the Burgess for
mundane reason that nothing new co
be collected (or so they thought). Harv
paleontologist Percy Raymond had fo
another unit sixty-five feet ab
Walcott's quarry in the early 1930s,
this second lentil had yielded much
and nothing new—and rumor held
Raymond had demolished his find
the same thoroughness and avidity
Walcott had displayed in eliminating
own. But the Geological Society of C
ada reopened the quarries in the mid
1960s, while the Royal Ontario Muse
collected more intensively and sought
sites in 1975 and from 1981 to 1984
D. Collins, D. Briggs, and S. Con
Morris, *Science*, vol. 222, 1983, p. 1
These Canadian teams found soft-bod
fossils at about a dozen sites represen
four additional stratigraphic levels
close to Walcott's original). These new
calities share the same setting—sl
units deposited in deepish water at
base of an algal reef. (If one unstable
bank could slide into a stagnant basi
form Walcott's original lode, why not
ers as well—thus explaining the multip
ity of soft-bodied bounties in such a
stricted area. The new localities extend
some fifteen miles along the Cathe
Reef escarpment.)

But our recent Burgess breakthro
was not primarily provoked by new sp
mens—for the additional localities did
substantially augment Walcott's fau
list. Rather, proper attention has fin
descended upon Walcott's precious o
nal specimens—and their first adequ
study has yielded a new and striking in
pretation. Many paleontologists, inc
ing some of the world's most kn
edgable anatomists of invertebrates, h
led the restudy of Walcott's fossils—
special praise goes to Harry
Whittington, professor emeritus of g
ogy at Cambridge, England, and to Si
Conway Morris, now also at Cambri
The promise of Walcott's material ha
nally been realized.

The new ideas about Burgess Shale
ganisms can be summarized in a sente
one that turns Walcott's interpretation
rectly on its head: Many Burgess anim
cannot be classified into any mod
group; their anatomies are unique.
other suite of fossils contains nearly
many oddballs.

We should have acknowledged
uniqueness long ago, even when the od
forms of all lay hidden within Walc
Vermes. About 37 percent of all Bur
organisms are arthropods, the most pro
nent element of the fauna. Some, part



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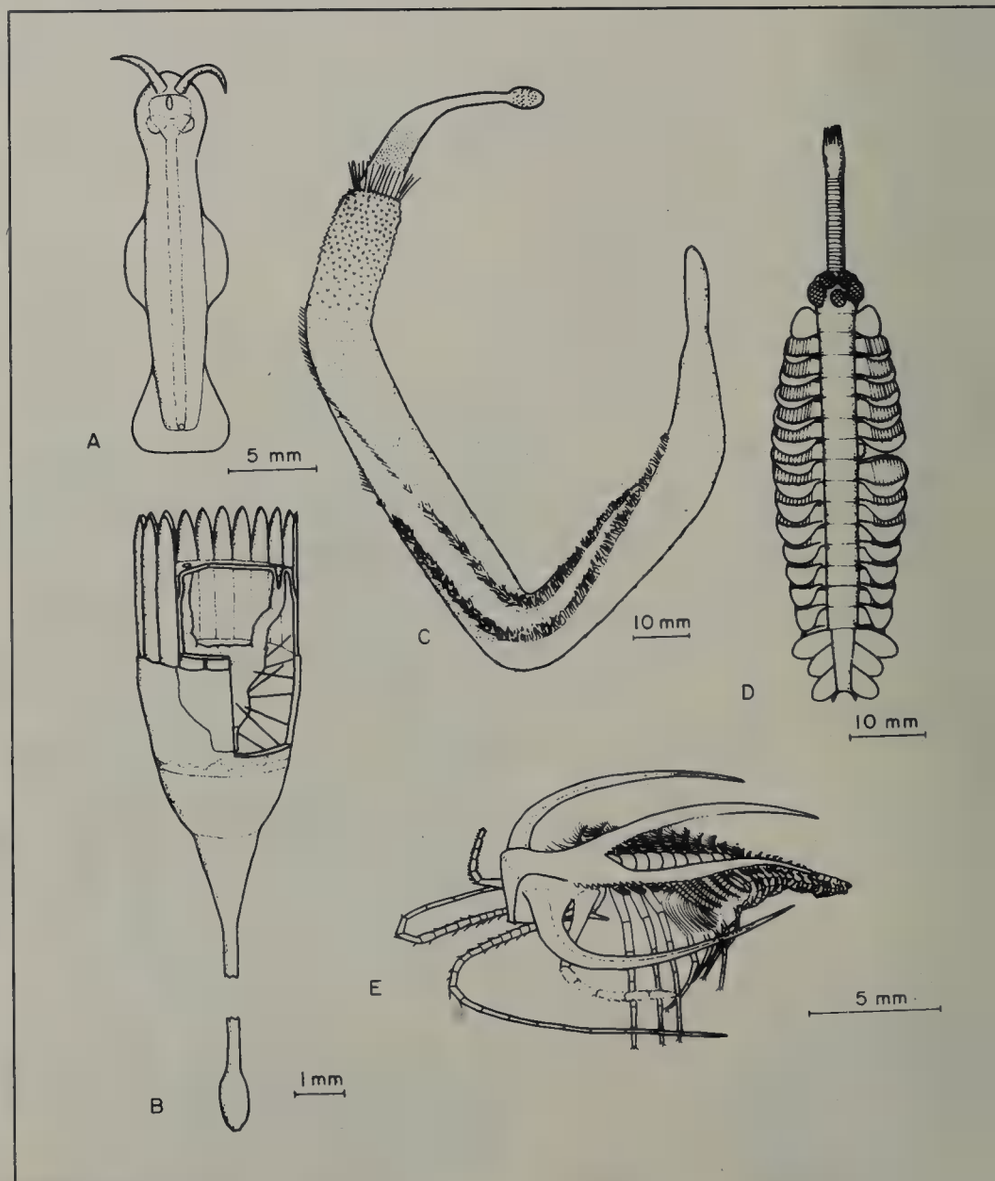
larly the trilobites, are comfortably placed within well-known groups. But many, including the most complex and exquisite of Burgess organisms, are acutely disconcerting for anyone with a passion for tidy order: arthropods they clearly are, but like no others. They bear the distinctive bits and pieces, but in arrangements, numbers, and proportions unknown elsewhere. Paleontologists responded to this assault upon taxonomic comfort by the usual strategy: they erected yet another wastebasket and called them all Trilobitoidea (or trilobite-like creatures). But this name hid a diversity of disparate animals, just as Vermes had provided a verbal rug to cover wider discomfort.

If many Burgess organisms represent unique designs within established phyla, then we need only crank up the argument one step to dismantle Walcott's Vermes (for as Trilobitoidea hid the oddballs among arthropods, Vermes sheltered the oddballs among *animals*). Simon Conway Morris has pioneered this revolutionary interpretation. ("Revolutionary" may be the most overused word in science today, and I shudder to write it—but how appropriate in this case.) Simon estimates th
about a dozen Burgess genera cannot
placed into any modern phylum, and th
their aggregate anatomical diversity m
span the entire range of invertebrate d
sign.

Consider just one picture from Simo
review of the Burgess Shale fauna (
Conway Morris, *Annual Reviews of Ec*
ogy and Systematics, vol. 10, 1979,
327). Simon drew this figure to illustra
representative Burgess organisms, not
focus upon oddballs (it doesn't even
clude *Hallucigenia,* weirdest creature
all—see my column of July 1983). E
Marrella splendens, most common of
Burgess animals and obviously an arth
pod, but of a kind unto itself. C is
priapulid worm, a dominant group with
the Burgess, but a minor component
most invertebrate faunas today. The oth
three creatures are mysteries. *Amisk*
sagittiformis (A) had been called a ch
tognath, but the similarities are supe
cial and the combination of characters
known elsewhere. *Dinomischus isola*
(B) supports a swollen calyx upon a sl
der stem. Elongate plates arise from



From *Annual Reviews of Ecology and Systematics,* vol. 10, 1979

nt end of the calyx, while both ends of a ved gut open at the top surface. *qbina regalis* (D), with five eyes at the e of a frontal process armed with teeth ts edge, is anybody's guess.

could focus this column directly upon s diversity, and produce a kind of bestiy, but such is not my way. I prefer clear l elegant cases, for castles are only so rable as their building stones. I have nted to write about the Burgess faunas years, but was only inspired by a parular study, Simon Conway Morris's nograph, hot off the press, of *Wiwaxia rugata,* yet another Burgess oddball Conway Morris, *The Middle Camian metazoan* Wiwaxia corrugata *(Matw) from the Burgess Shale and* ygopsis *Shale, British Columbia, Cana, Philosophical Transactions of the yal Society of London,* vol. 307, 1985, 507–586). Which leads to . . .

TRODUCTION 3: The science that ches our newspapers and magazines is mall and biased subset of the interest- work done by professionals. Talks at blic meetings and short articles in such neral journals as *Science* and *Nature* ke their easy way into public consciousss, but science writers rarely read the sic repositories of technical informan—the specialty journals and, particuly in my field of systematics, taxonomic nographs. I regret this system of closed d open channels because so much of the st instructive and exciting science in profession appears, traditionally and propriately, in these long descriptive mpendia that never see general light, ough they move our profession forward proper attention among small groups of perts.

The *Philosophical Transactions of the yal Society of London* (or *Phil Trans* the cognoscenti) is the oldest, contin- lly published, scientific journal in Eng- h. It printed the works of Newton in the venteenth century, and it continues to blish the basic data of science today. y colleague Simon Conway Morris has t presented, in this venerable journal, a -page (and 173-picture) monograph on inch-long invertebrate that lived 530 llion years ago—the very sort of docuent that science writers rarely see or diss, and a great pity in this case, for Sion's monograph has something portant to tell us all. We must somehow rn to respect the basic data of science, t only its flashy theories.

The body of *Wiwaxia corrugata* is a ttened, elongated oval, averaging enty-six millimeters (about an inch) in gth and ten millimeters in maximum height (excluding spines); the champ that didn't get away measures fifty-two millimeters in length. The basic form of the body is simple: no segments, no demarcation of head, trunk, or tail, no sensory organs—basically an uninterrupted oval in outline. (We can make a reasonable inference about fronts and backs and tops and bottoms because a food-gathering apparatus occupied the front end of an apparently straight gut; one surface, presumably the bottom, was naked, while the opposite side carried two projecting rows of spines.)

Upon this uninspiring basic body, *Wiwaxia corrugata* sports a distinctive feature that places it among the most conspicuous and intricate of Burgess Shale organisms: the body (except for the naked belly) is covered with sclerites (projecting blades of stiff, but nonmineralized, tissue), each attached into an indentation of the body surface by a single rounded or pointed root.

The sclerites of *Wiwaxia* grew in two different styles: flattened *scales* (ornamented with parallel ridges) cover most of the body, while two rows of *spines* emerge from the top surface, one on each side of the central axis (see figure of Simon's re-

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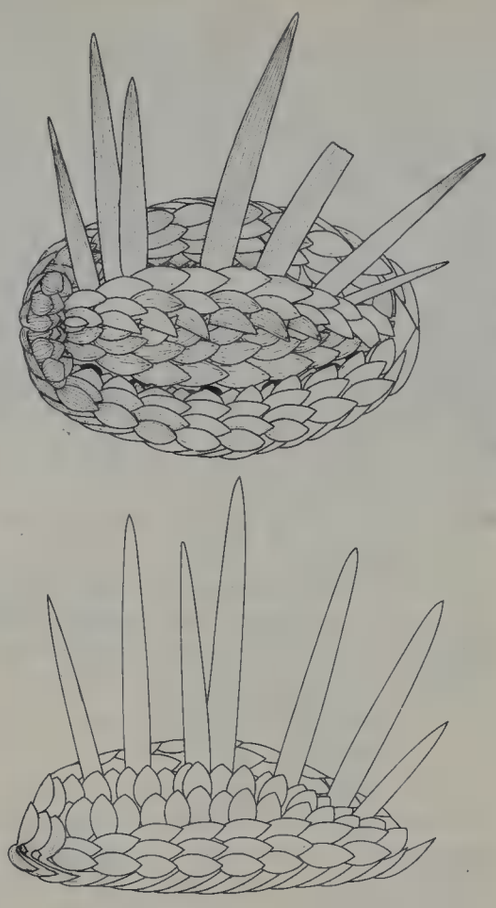


Simon Conway Morris's reconstruction of *Wiwaxia corrugata*. From *Philosophical Transactions of the Royal Society of London*, vol. 307, 1985, p. 560

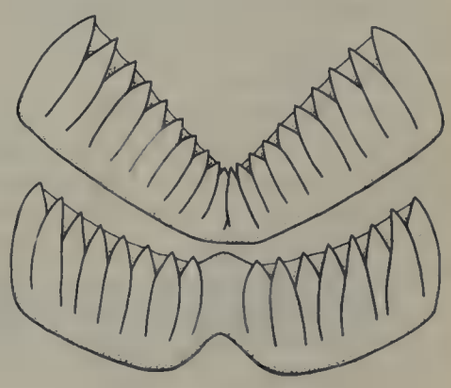
construction). The sclerites grew in an ordered arrangement—a field of overlapping blades on top, arrayed as six parallel rows (top view of the figure) and two regions on each side (bottom view), two upper rows with sclerites pointing upward and two lower rows with sclerites pointing backward. We find, however, no sign of regular segmentation within these ordered fields.

Simon could see little of *Wiwaxia*'s internal anatomy—some hints of a straight gut perhaps, but not much else. One feature, however, may be important in judging the biological relationships of *Wiwaxia*. About five millimeters from the anterior end, Simon found two arcuate bars, each carrying a row of simple, conical teeth directed toward the rear. The front bar bears a notch at its center, marking a toothless area between side regions bearing seven to eight teeth (see figure); the rear bar has a straight margin with teeth all along the other edge. These structures were probably attached to the bottom of the gut. By this evidence of form and position, their interpretation as feeding devices seems well founded.

Simon could make other inferences beyond adult anatomy. The absent or relatively small spines of small specimens indicate change of form with growth. Two juxtaposed specimens seem to represent an act of molting by one individual, not two animals accidentally pushed together in the turbidity slide that buried the Burgess fauna. The smaller specimen is shrunken and elongate, as if the larger body had just crawled out, leaving its old surface behind as "a vacated husk." Small brachiopods, occasionally attached to a sclerite, indicate that *Wiwaxia* crawled along the top of the sediment; it did not burrow within (where the brachiopod could not have survived). Patterns of breakage in several spines may point both to the activity of predators (presumably among the arthropods) and the possibility of escape. The feeding bars seem to indicate a life spent scraping algae or gathering detritus on the sea floor. In short, *Wiwaxia* was probably an herbivore or omnivore, living on small items of food collected from the sediment surface as it crawled along the sea floor. We can learn quite a lot from a few flattened films preserved on shale beds—and the neglected literature of taxonomic monographs houses this information in all its fascinating detail. (The stringent space limitations of most professional journals do not permit the leisurely pace and complex development that such presentations require.)

Simon may have reconstructed the anatomy of *Wiwaxia* and inferred its mode of life with signal success, but we are left with the biggest of all mysteries. What is it, genealogically speaking?

Walcott christened the genus *Wiwaxia* in 1911 (after the local name for a neighboring group of small mountain peaks). He placed it among the worms, with all other Burgess mysteries—in this case into the class Polychaeta (the dominant group of segmented marine worms). An ironic story surrounds an earlier, and first, discovery of *Wiwaxia*. In 1899, G. F. Matthew described a single spine of *Wiwaxia* from the *Ogygopsis* bed below Walcott's Burgess quarry (then undiscovered). (Isolated sclerites of *Wiwaxia* are stiff enough to resist decay and be preserved in ordinary fossil beds, but complete specimens are known only from the Burgess Shale



From the Royal Society's *Transactions*, p. 558

Smithsonian Archi

Fossil collecting in 1913 at the Burgess Shale on the west slope of Mount Wapta, British Columbia

lentils.) Matthew described this single spine as a hyolithid of the genus *Orthotheca*. Hyolithids are now regarded as yet another oddball group of uncertain affinity, probably meriting a separate phylum in their own right. Did Matthew, then, begin *Wiwaxia*'s history with a proper note of genealogical uniqueness, though in the wrong scale? Scarcely. Matthew, applying the conventional shoehorn of his day, placed hyolithids among the annelids—so *Wiwaxia* resided in Vermes from the start.

As Simon argues convincingly, *Wiwaxia* won't work as an annelid (segmented) worm. Beyond the meaningless externality of its oval shape and bilateral symmetry, nothing about *Wiwaxia* says annelid or any kind of recognized worm. Neither its body nor its sclerites show the slightest sign of segmentation (a defining character of Annelida); it lacks setae (the movable bristles of most annelids), and its sclerites are not built like plates and spines that adorn some annelids.

Might another modern phylum be a possible candidate? The two feeding bars do recall a defining character of mollusks—the radula (also a bar of teeth lying at the anterior end of the gut). But little else suggests affinities with clams, snails, and their ilk. *Wiwaxia*'s body form and mode of life seem most unmolluscan (though a little-known group, the Aplacophora, does include unshelled, basically wormlike creatures with radulae). But mollusks do not grow by molting, and none has a structure anything like the defining sclerites of *Wiwaxia*.

Simon concludes that *Wiwaxia* and its allies (the isolated sclerites found in other Cambrian deposits) deserve a phylum of their own, perhaps closer to mollusks than to other living groups, but still distinct. Perhaps, he argues, several related body plans of a "supermolluscan" lineage vied during these early days of life's history, most dying in the low diversity of youth (wiwaxiids and hyoliths, for example); one—the true mollusks—surviving and radiating. As an alternative of even more mystery, the tenuous link to mollusks may be illusory and based on independent evolution of a similar feeding organ—and *Wiwaxia* may bear no recognizable relationship, however vague and distant, to any modern group.

Thus, the Burgess story gets curiouser and curiouser as the restudy of Walcott's specimens proceeds apace. The new invertebrate phyla from this single locality may eventually reach half the number of those inhabiting our entire earth today (about twenty to thirty by various counts).

I must emphasize—to define the depth of this intellectual puzzle—that the Burgess is no ordinary soft-bodied fossil fauna. Such faunas are rare indeed, but several exist (including the famous lithographic limestone of Solnhofen, home of *Archaeopteryx,* the first bird), and none contains anything like the diversity of the Burgess Shale. In particular, no other soft-bodied fauna collection includes more than one or two unplaceable oddballs, while the Burgess may house more than a dozen. Why this difference?

The Burgess (fortunately for us) occupies a crucial time in life's history. It represents our only "window" upon the first great radiation of complex life on earth. All but one or two modern phyla originated in a burst of evolutionary activity associated with the so-called Cambrian explosion some 570 million years ago. The Burgess provides our only peek at the soft-bodied forms of this first flowering. All other soft-bodied fossil assemblages are much younger; they represent faunas well past the initial burst and sorting out of Cambrian times.

I wrote a previous column on this aspect of the Burgess mystery (July 1983). I argued that a pattern of "early experimentation and later standardization" underlies this initial burst and later restriction of taxonomic mysteries—the Burgess Shale should abound with phylum-level body plans of low diversity and limited range. the Cambrian explosion represented t first flowering of modern multicellul life, then we might anticipate an init phase of vigorous experimentation with permutations of possible designs and later restriction and sorting out of best lutions (or, perhaps, merely of lucky sur vors among varied opportunities). I d cussed possible explanations for t pattern, primarily contrasting the hypot eses of improvement in anatomical en neering versus simple good fortune—a will not treat this fascinating topic any fu ther here. I want, instead, to close by d cussing a different issue, previous avoided: *how* could early multicellular l generate so many radically different bo plans so fast? Life is not producing t kind of diversity today.

This dilemma has two potential kinds solutions. The first, traditional for mo than a century and only recently under rious challenge, holds that no proble really exists—that the appearance of u usually rapid evolution at the Cambri explosion is an artifact of our imperfe fossil record. The artifact theory comes several versions (I will discuss Walcott's next month's column). The most plausil scenario holds that Precambrian multic lular life had a long history of gradu development, leading in continuity towa the products of the Cambrian explosi but that Precambrian faunas were all so bodied and, therefore, not preserved. T Cambrian explosion only marks the evo tion of hard parts (perhaps reflecting change in oceanic chemistry or the evo tion of predators that might encour such a defensive response), not the orig of anatomical complexity.

If the artifact theory is correct, then f get the rest of this essay (but don't be a noyed; I've given you a fair amount good stuff already). But several events the past two decades have seriously wea ened this venerable theory, perhaps tally. Our knowledge of Precambrian a

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Cambrian stratigraphy has improved to the point where "it's there, but we haven't found it yet" becomes increasingly more implausible. Moreover, we have found an extensive fauna of soft-bodied Precambrian creatures (the Ediacara assemblage—see my column of February 1984), and they neither match in diversity nor seem ancestral to the Cambrian soft-bodied creatures of the Burgess Shale. In a strikingly new interpretation, Adolf Seilacher has argued that the Ediacara animals are not, as previously argued, ancestral to the Cambrian fauna, but a separate experiment in multicellular life, wiped out in a previously unrecorded mass extinction just before the Cambrian explosion. If this interpretation holds, then the Cambrian fauna must be new to the Cambrian (or we would have found its representatives in the Ediacara beds).

The second solution regards the unparalleled explosion of Cambrian body plans as a real and rapid event. Explanations for this reading come in two broad categories—traditional and conventional. (I suspect that the correct solution will combine a bit of both, but I profess strong fondness for the unconventional argument.)

The conventional theme, based upon a world run by Darwinian natural selection, holds that there never was a time quite like the Cambrian—and that the anatomical explosion was a response to this ecological uniqueness. Multicellular life of modern aspect had evolved but recently, and it faced an empty world, teeming with ways for making a living and ripe for exploitation. Ecosystems had room for everything—crawlers, walkers, burrowers, slurpers, predators, parasites, you name it—and life responded with an unparalleled seizure of opportunity, vigorously overshooting the mark (early experimentation) and then sorting out the best competitors (later standardization). Once exploited in the Cambrian explosion, such an opportunity could never arise again because the earth's oceans never became so empty. Even after the great Permian extinction, which removed 96 percent of all marine species by one estimate, no comparable radiation greeted the subsequent Triassic because at least one of every major design survived the debacle, and basic body plans did not disappear.

The unconventional theme does not deny this powerful impetus from an empty world, but argues that genetic systems, as well as environments, might have been different in the Cambrian. (The conventional explanation looks only to environments and implies that a similar explosion would occur now if a mass extinction ever emptied the oceans to earliest Cambrian leve of organic complexity and diversity.) U der traditional Darwinian views, mo phologies have histories that constra their future, but genetic material does n Genetic systems do not "age." Diffe ences in rates and patterns are respons of a similar material substrate (genes a their actions) to variations in environme that set differing pressures of natural s lection.

But perhaps this usual view is wron Maybe genetic systems do "age" in t sense of becoming "less forgiving of maj restructuring" (to cite a phrase from J. Valentine, who has thought long a deeply about this problem). Perhaps mo ern organisms could not spawn a rapid a ray of fundamentally new designs, no ma ter what the ecological opportunity.

I have no profound suggestions for t potential nature of this genetic "agin but simply plead that we bear such an ternative firmly in mind. Our explodi knowledge of development and the m chanics of genetic action should provi within a decade, the facts and ideas flesh out such a conception. Valenti mentions some possibilities. Were Ca brian genomes simpler and more flexibl Does the evolution of multiple copies so many genes, copies that then diver into a range of related functions (see la month's column on the homeobox), tie genomes into webs of interaction not ea ily broken? Did early genes have fewer teractions with others? Did early orga isms develop with more of a one-to-o translation of gene to product, permitti such animals to interchange and alt their parts separately? Most important, increased complexities and regularizati of development from egg to adult put brake upon potential changes of gre magnitude?

We cannot yet go beyond such cru and preliminary suggestions. I have no ing new or useful to offer in this area, bu wish to present, as a final point, an arg ment for the unconventional view that h been overlooked—one that strikes me important.

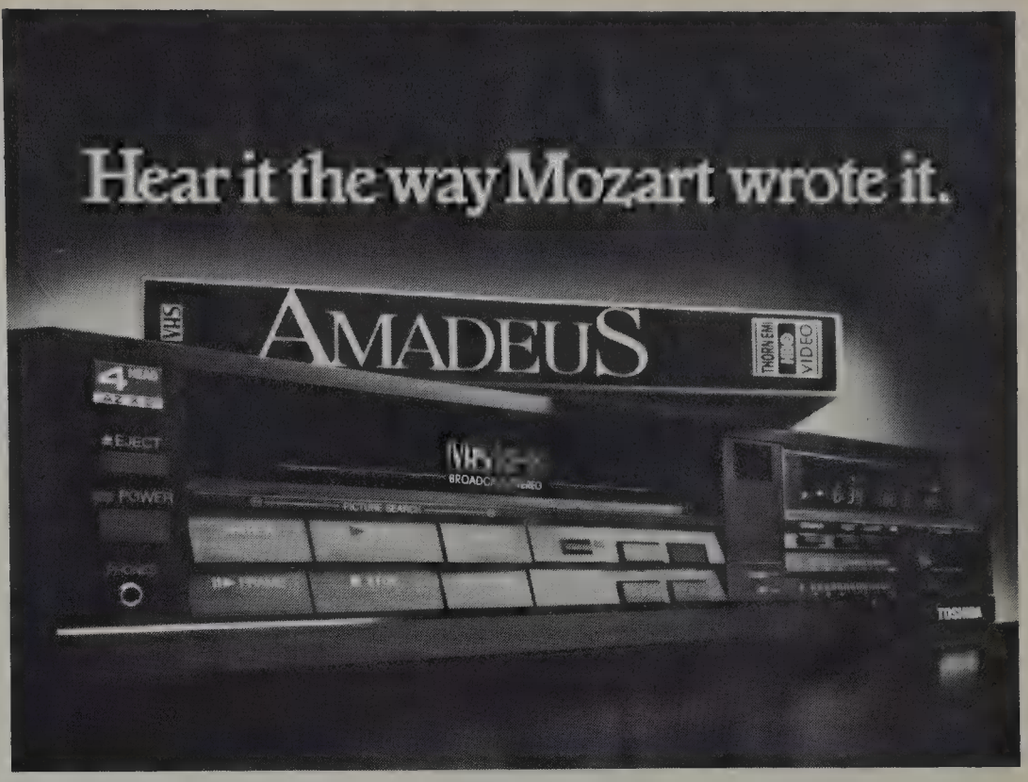
A false and usually unstated assum tion underlies our preference for the tra tional view that ecological opportun alone spawned the Cambrian explosi When evolutionists note that several un lated lineages react in the same way at t same time, we assume that some force e ternal to the genetics of organisms has p voked the common response (for the g netic systems are too unlike, and a simi push from outside seems the only plau ble common cause). We have alwa viewed the creatures that made the Ca

an explosion as unrelated in just this found way. After all, they included resentatives of nearly all modern la, and what could be more different n a trilobite, a snail, a brachiopod, and echinoderm. These morphological de- ns were as distinct in the Cambrian as y are today, so we assume that genetic tems were equally unlike—and the nmon behavior of all groups, that is, ir simultaneous vigor in evolving new igns, must therefore record the exter- push of ecological opportunity.

But I remind everyone that, particu- y if Seilacher's view of the Ediacara na holds (the claim for their nonan- tral nonlink to modern designs), then Cambrian animals, despite their diver- of form, were little removed in time m their union in a common ancestor. Cambrian animals may have sported a y similar genetic mechanism by virtue their strictly limited time of separate . No ties bind so strong as the links of eritance. In other words (and in the bio- ical jargon), the similar response of mbrian organisms may reflect the *ho- logy* permitted by a genetic system still d largely in common, not only the *anal- y* of a response by different systems to a mmon external push. Of course, life eded the external push of ecological portunity (I do not deny this part of the ditional claim), but its ability to re- ond may record a genetic heritage, then mmon and now dissipated.

This prospect suggests an intriguing re- erpretation of life's history. We know at the quirky and opportunistic paths of story shape the patterns of life's form d diversity through time. But we have sumed that the basic machinery (ge- tic systems and their response to natural lection) has operated in the same way, at ast since the evolution of our modern ayla. As continents wander in curious ths, but principles of plate tectonics re- ain the same, we have argued that or- nisms follow unique, directional, and nrepeatable pathways, but that material bstrates have no important history. But rhaps history is more pervasive than we ve thought. Perhaps we cannot escape s constraints and find a comfortable set underlying timeless objects that will enerate the uniqueness of observed re- lts from an unchanging core. Perhaps e core evolves too, in profound and dif- rent ways from the phenomena that it enerates. Perhaps history is the deepest ommon principle of all.

tephen Jay Gould teaches biology, geol- gy, and the history of science at Harvard niversity.



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Terror of the Trilobites

Paleontologists took a second look at a famed fossil site and unearthed the giant predator of the Cambrian period

by Derek E. G. Briggs and Harry B. Whittington

The discovery of British Columbia's Burgess Shale, as well as other fossil-bearing shales nearby, is one of the most important events ever to occur in paleontology. The shale's great value arises partly from the rare and exquisite preservation of soft-bodied creatures, but the find is even more remarkable because two-thirds of the fossils are from animals that were virtually unknown to science.

By studying these fossils, we are opening a large window on life 540 million years ago, during the middle of the Cambrian period. We have also solved some fascinating puzzles in the fossil record.

Since Charles Doolittle Walcott discovered the Burgess Shale three-quarters of a century ago (see Stephen Jay Gould's column, page 22), some 140 species from these rocks have been identified. Only about one-third of these species have the skeletons or shells commonly preserved in fossil-bearing rocks of the Cambrian period. The rest, being soft-bodied, are a fossil cache of great rarity and value and are still providing paleontologists with clues to middle Cambrian life and times.

In 1966, the Geological Survey of Canada began a reinvestigation of the Burgess Shale with a new excavation of Walcott's quarry. As part of the team, we have studied new, as well as previously collected, fossil specimens, among them the unusual creatures first described by Walcott. One of the most puzzling organisms, from the famed Fossil Beds of Mount Stephen, about two miles southeast of the Burgess Shale, had been described in 1892 by a paleontologist of the Canadian Geological Survey, J. Whiteaves. The name Whiteaves chose for the fossil, *Anomalocaris* ("unlike shrimp"), revealed his uncertainty about the animal's status. *Anomalocaris* fossils from both the Burgess Shale and Mount Stephen were tapered and segmented, with each segment bearing a pair of spines. Both Whiteaves and Walcott believed the fossils to be the body of a large, bivalved crustacean, from which both sides of the protective covering, or carapace, had become detached (a carapace was never found attached to the body). Walcott also described a "jellyfish," a flattened, circular structure with thirty-two radial divisions, as well as a large, isolated appendage bearing a long, comblike series of blades, each with an array of spines. This limb, informally dubbed appendage F, was adapted for capturing prey. Because it was jointed, Walcott guessed that the limb belonged to an arthropod. Arthropods, such as modern insects and crustaceans, have an exoskeleton, segmented body, and jointed limbs. Walcott even assigned the limb, incorrectly, to the genus *Sidneyia,* which also occurs in the Burgess Shale. Appendage F, the jellyfish, and the segmented *Anomalocaris* were thus classified, but nothing more was learned about them during the next seventy years.

Our observations make it clear that Whiteaves and Walcott were mistaken when they labeled the segmented *Anomalocaris* as the body of an arthropod. None of the fossils shows any traces of a gut, a part often preserved in other animals in the shale. Moreover, the joints are hinged in a most unusual manner for those supposed to be of the trunk skeleton. We realized that what Whiteaves, Walcott, and later authors thought to be a complete body was just an isolated limb. This "tip of the iceberg" led us to speculate on the size of the whole organism. Some of the limbs reached lengths of eight inches—gigantic by Cambrian standards.

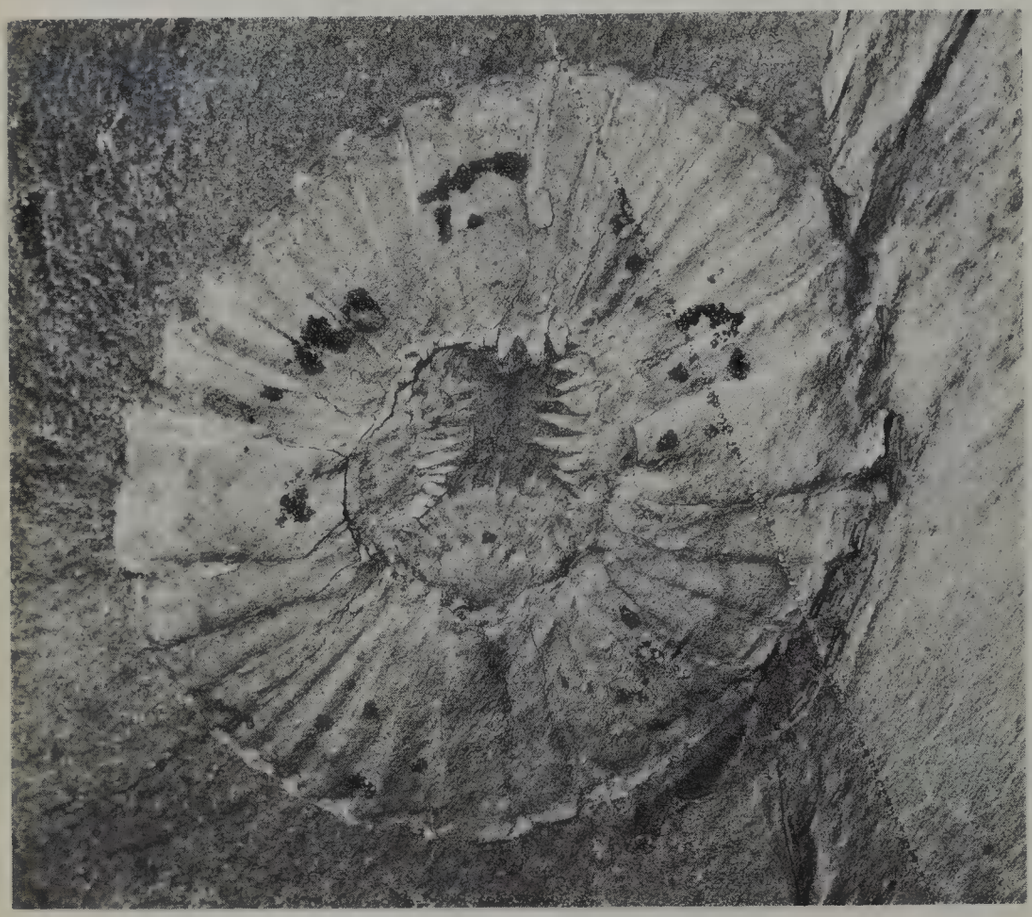
In 1981, Whittington began work at Cambridge University on specimens of a large undescribed animal from Walcott's collection and on one specimen from the Geological Survey of Canada collection. As he applied a dental drill to the stone overlying the Geological Survey fossil, he discerned a pair of *Anomalocaris* limbs attached to the specimen's head.

Further investigation fleshed out the creature and solved longstanding puzzles. When we examined Walcott's material, we saw that other specimens had preserved head limbs that matched appendage F. One had a circlet of plates where the mouth ought to be, a ring identical to Walcott's jellyfish. Its consistent position in a number of specimens ruled out its accidental superimposition on any other fossil animal. Not a jellyfish, but part of the body, the ring was a circlet of jaw plates.

The Cathedral Crags of British Columbia, below, are the remains of a massive limestone reef deposited by millions of generations of lime-secreting marine algae. A belt of limestone fringed the American continent in the mid- to late Cambrian, 540 to 505 million years ago. The Burgess Shale animals lived on and in muddy sediments that accumulated along the reef front.

All photographs by Derek E. G. Briggs and Harry B. Whittington

A fossil of an Anomalocaris *jaw, below, reveals a ring of jaw plates and an inner battery of teeth. The jaw plates are more often preserved than soft parts of* Anomalocaris *because they are more resistant to decay. The giant of the Cambrian period,* Anomalocaris, *right, reached lengths of eighteen inches. The jaw circlet and the grasping appendages on the head indicate that the animal was a predator, while the flat lobes flanking the trunk (incomplete due to breakage of the slab) attest to its swimming skills.*



The largest of the complete *Anomalocaris* specimens is about seven inches long, but the size of isolated limbs and jaw plates leads us to believe that individuals reached lengths of eighteen inches. This animal is the largest Cambrian creature ever found and was the giant predator of its time. We think two similar species existed, one having a pair of *Anomalocaris*-type limbs at the front; the other, a pair of appendage F's.

The relative abundance of isolated limbs and jaw circlets indicates that they were more resistant than the rest of the body to decay. These parts are rarely found in association, however. Limbs and jaws, shaped respectively like hollow tubes and disks, would behave very differently when carried by water currents.

Were soft-bodied animals, though scarce in the fossil record, actually common denizens of the ancient Cambrian environment? While the Burgess Shale, the only site yielding complete specimens of *Anomalocaris,* is exceptional, evidence indicates that the assemblage of animals the rock contains was typical of Cambrian seas. The discovery of soft-bodied Burgess Shale animals at more than a dozen new localities, nine yielding parts of *Anomalocaris,* provides further evidence that the Burgess Shale fossils are widespread and representative of Cambrian life.

How did *Anomalocaris* operate in its Cambrian world, and how did it interact with the animals sharing its habitat? Our reconstructions show it to have been an agile swimmer and an efficient predator. Spiny, segmented limbs flanked the jaw plates, and a pair of large eyes sat well back on the sides of the head. The trunk bore a series of large overlapping fins, or lobes; overlying these lobes were possible gills. The lobes probably moved up and down in succession, creating a propulsive wave running the length of the trunk; thus the animal swam like a fish with a long lateral fin, such as a stingray's. The body outline also resembles that of a cuttlefish, which also uses undulations of the lateral fins for maneuvering, although jet propulsion is its normal mode of swimming. The triangular, horizontal lobes of *Anomal caris* could hardly have been used as oa to paddle the animal along because th would not fold or collapse during a rec ery stroke, to reduce drag in the manner a "feathered" oar. Rather, *Anomaloca* was unique in swimming by generating wave with a series of separate lobes rath than along a continuous fin. The dr caused by the gaps between the lobes m have been offset by the thrust created water was forced out from between the The animal may have been coordinat enough to reverse the propulsive wave a swim backward, to adjust the waves on posite sides of the trunk to turn, and ev to hover.

Anomalocaris was well suited to life as carnivore. The pair of front limbs cap-red prey and pushed it toward the cir-et of plates making up the jaw. Its grasp-g appendages and swimming skills early enabled *Anomalocaris* to capture imals of the sea bottom.

The most abundant bottom dwellers eserved in the Cambrian fossil record e trilobites, marine creatures that had a rd exoskeleton divided into three sec-ons and that grew, like modern crusta-ans, by molting, thereby producing nu-erous fossils. Although preserved traces *Anomalocaris* gut contain no recog-zable prey fragments (such as broken ts of shell), trilobites found at a number of Cambrian localities, including the Fossil Beds on Mount Stephen, are marked by bites, usually in the tail shield. These trilobites are the survivors of attacks, much as seals or other marine mammals bear evidence of shark or *Orca* strikes. The wounds have healed around the margins; less fortunate victims were presumably bitten in critical areas. While *Anomalocaris* is likely to have fed extensively on the abundant arthropods that lacked the heavily mineralized skeleton of trilobites, its bulk and efficient toothed jaws make it probable that Cambrian trilobites were part of its diet.

Circumstantial evidence also suggests a predacious interest in armored animals. Because the "teeth" did not meet, the jaw could not have bitten clean through prey but may, in combination with the appendages, have worked like a nutcracker to break the exoskeleton of trilobites. The shape and overlap of the jaw plates form two wider openings, aligned diagonally across the circlet. If a large trilobite was turned on its side and the edge pulled into one of those openings, the resultant break would be shallow. The bite itself was probably in the form of an asymmetric W. Some marks inflicted on trilobites found at Mount Stephen and in middle Cambrian rocks in Utah (where *Anomalocaris* also occurs) have such an outline.

Predation is important to an understanding of ancient ecology because the food chain helps determine the structure of biological communities. The jaws and appendages of *Anomalocaris* attest to its carnivorous role; the bitten trilobites show that it (and perhaps other large predators) were capable of breaking mineralized skeletons, a process known as durophagy. Other animals from the Burgess Shale also had limb structures or gut remains suggesting they were predators. The limbs of one fossil trilobite indicate that it was a predator in its own right; other trilobites were scavengers, deposit feeders that grazed on organic matter from the sea floor, or filter feeders that gathered food particles suspended in the water. Ways of eating, such as carnivory, and ways to keep from being eaten proliferated. Even by the Cambrian, then, predation was a vital factor controlling the structure of communities and promoting the evolution of protective strategies. The pressure to develop defense tactics ultimately served at least some of the prey well, as they flourished throughout the Cambrian period and beyond. The armored trilobites, for example, survived about another 300 million years into the Permian period.

The tough exoskeleton of trilobites, such as Ogygopsis, *below, was no guarantee against attack. The specialized jaws of* Anomalocaris *may have acted as a nutcracker to penetrate the hard covering. The bite mark on the right side of this animal's tail shield tells the story of the trilobite that got away.*

Taxonomy, the classification of animals into related groups, is often a matter of great debate for paleontologists. Much of the discussion of arthropod evolution has centered on the problem of whether the presence of a particular character in two groups indicates relationship (common ancestry) or independent evolution of a trait in response to similar environmental and selection pressures (convergent evolution). *Anomalocaris* provides striking evidence that at least one important character of arthropods, the jointed limb, could have evolved independently in two or more major groups of animals.

Apart from the limbs and segmentation of the trunk, *Anomalocaris* is unlike any

An astounding variety of shelled and soft-bodied animals inhabited Cambrian seas.

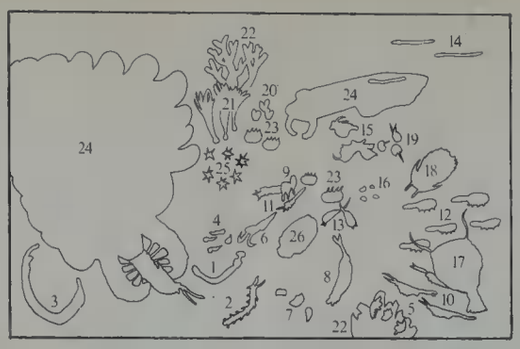
1. *Ottoia,* priapulid worm
2. *Burgessochaeta,* annelid worm
3. *Louisella,* priapulid worm
4. *Hyolithus,* mollusklike animal
5. *Aysheaia,* arthropod
6. *Leanchoilia,* arthropod
7. *Nisusia,* brachiopod
8. *Opabinia,* affinity uncertain
9. *Dinomischus,* affinity uncertain
10. *Waptia,* arthropod
11. *Yohoia,* arthropod
12. *Canadaspis,* arthropod
13. *Molaria,* arthropod
14. *Pikaia,* chordate
15. *Marrella,* arthropod
16. *Scenella,* mollusk

arthropod. The combination of plated jaw and overlapping trunk lobes and consequent mode of swimming precludes the assignment of *Anomalocaris* to any living group. If we discovered such a creature in the deep sea today, we would readily designate a new phylum to house it.

Anomalocaris was one of a great mosaic of body forms that evolved during the late Precambrian/early Cambrian, the time of the first great adaptive radiation of multicelled animals, arguably the most important event in the entire evolutionary course of multicelled life. Early in this radiation, or filling of ecological niches by new forms of life derived from common ancestors, competition between different kinds of animals may have been limited, giving rise to the evolution of an unsurpassed variety of body plans. But when a phylum (such as that including *Anomalocaris*) became extinct, no new, unique group seems to have replaced it. Rather, the vacated niche was filled by diversification of other existing stocks, and the range of phyla was thereby reduced. Why some phyla succeeded and others failed—why arthropods, *Anomalocaris*'s prey, should include the most abundant and diverse living groups, such as modern insects, while *Anomalocaris* disappeared after the middle Cambrian—is unclear. Chance may have played a role, but we surmise that the body plan of *Anomalocaris,* with one pair of jointed limbs, overlapping lobes, and radial jaw, had less long-term adaptive potential than that of arthropods, with serial repetition of branched limbs.

Modern perception of the diversity of animals in the Cambrian depends largely on the quality and extent of the fossil record. The Burgess Shale helps balance a fossil record biased toward animals with hard parts and offers a rare, three-dimensional view of Cambrian life. Trilobites, so abundant as fossils, were just a part of a broad scenario and were stalked by the *Tyrannosaurus rex* of their time. The Burgess Shale has revealed the unsuspected abundance of soft-bodied Cambrian creatures and has shown that more than 500 million years ago, forces familiar today, such as predation, were already shaping the evolution of ancient life. □

Sidneyia, arthropod
Olenoides, arthropod (trilobite)
Burgessia, arthropod
Pirania, sponge
Echmatocrinus, echinoderm
Vauxia, sponge
Wiwaxia, affinity uncertain
Anomalocaris, affinity uncertain
Choia, sponge
Ogygopsis, arthropod (trilobite)



Janice Lilien

Brazilian couple collect fruit of the babassu palm, which provides many landless people with food, fuel, and shelter. The palm takes over any cleared area and now occupies large sections of Maranhão.
J. Balick

A "Tree of Life" Grows in Brazil

In the Brazilian state of Maranhão, the poor carve out a living from an all-purpose palm

By Anthony and Suely Anderson

Anthony Anderson

Agriculture has never been an easy proposition in the humid tropics. Trying to grow a crop and simultaneously hold off the bewildering number of plants that invade any cleared area requires enormous effort. Of course, many of the people who traditionally farm in the tropics are shifting cultivators. These growers minimize their efforts by clearing small patches of forest, which they use for a year or two and then abandon. The fields are quickly taken over again by the forest.

This ephemeral form of agriculture works fine when population densities are low. But in recent years more and more settlers have poured into the tropical lowlands. At the same time, much land has fallen into the hands of a wealthy few. The result is that shifting cultivation has broken down: with more people using less land, farmers cannot give sites a long enough rest. This reduces their harvests and eventually degrades the soil.

In many places, ranchers have taken over. They acquire large tracts of forest and clear them, turning them into pastures for cattle. Like the cultivated land, these areas are subject to degradation—from erosion, trampling of soil, and weed infestation. And ultimately, both these forms of land use have had the same result: wide areas of some of the most biologically rich places in the world have become agriculturally unproductive and economically impoverished.

But in frontier areas along the southern edges of the Amazon Basin, and particularly in the Brazilian state of Maranhão, nature has found a way to resurrect the lost land. Abandoned fields and croplands have been taken over by palm trees. The palm tree known as babassu (*Orbignya phalerata*) is a stubborn competitor that keeps other species from gaining a foothold. In fact, the forests it forms are so pure and uniform that travelers who have never seen them before often mistake them for plantations. That is a reasonable conclusion because local inhabitants can often be seen working among these palms, gathering fruit and cutting leaves.

But the immense stands of babassu in Maranhão occur naturally, and most of the people who use them are landless. For these people, babassu palms are a crucial source of food, fuel, shelter, and income. The story of where the palm came from and how people have come to depend on it tells something about life in frontier areas of the Brazilian Amazon and how human activities there, in conjunction with a natural process, may point to more successful ways to use land in the tropics.

Pure stands of babassu palm probably started to form in Maranhão after the arrival of Europeans in the 1600s. The colonists set up rice, cotton, and sugar cane plantations on bottom lands all over the state. The stands were probably not extensive initially and were largely confined to bottom-land areas. But in 1888, slavery was abolished and the plantation economy collapsed. Former slaves, and later their descendants, spilled out of the lowlands and entered the original forests, which they cleared. Wherever these shifting cultivators left a field fallow, babassu took over and turned the fields back into forests. In time, pure stands of the palm spread across the landscape.

Today babassu palm forests cover extensive areas of Brazil. In Maranhão, where we recently spent two years studying the palm, these forests now occupy an area roughly equal to the state of Virginia.

How do young babassu palms capture a deforested site? To understand that, one first has to know something about the palm's ecology in the uncut forest. There are tremendous numbers of young ba-

Randall Hyman

Human colonization of the Amazon Basin has sped the spread of the babassu palm, for wherever original forests are cut down for farming, babassu eventually takes over. Almost everything that grows on the plant has proved useful to local people. At right, a family heads into a hilly forest to gather babassu fruit. The husks of the fruit are used to make charcoal, below. People burn the husks in a shallow pit and continue to add organic material until carbonization occurs. In one district of Maranhão, more than 96 percent of the homes use babassu charcoal as the sole energy source.

Anthony Anderson

bassu plants growing in the primary forest. When we surveyed an undisturbed, species-rich forest in central Maranhão, we found more than 2,500 juvenile palms per acre. One reason the babassu palm does so well there is that its fruit has a two-inch-thick husk. It takes five and one-half tons of force to break one open; no mammal currently in Maranhão (or anywhere else in the American tropics) has that kind of strength. Only human beings with axes can get at the oil-rich seeds.

Today the only important nonhuman seed predator is the bruchid beetle *Pachymerus nuclearum*. The larvae of this beetle skirt the thick fruit wall and slip in through the germination pores located at the base of the fruit. Still, they rarely eat all the seeds. Our studies have shown that although 70 percent of the fruit are colonized by bruchid beetles, only about 20 percent of them lose all their seeds. At least one seed per fruit usually escapes predation and is able to germinate. In other words, just about every single time a babassu fruit drops in the primary forest, the result, sooner or later, is a new palm tree.

Germination begins approximately three months after a fruit falls and—also key to the success of the juveniles in the forest—is actually enhanced in the shaded understory. But babassu grows extremely slowly. We found that palms growing in a mature forest often didn't start reproducing until they were more than 70 years old. Babassu apparently can withstand long periods of low light. And it lives an unusually long time—the oldest tree we found was, by our estimates, 184 years old. Rather than usurping resources by rapid dispersal or growth, the babassu palm simply outlasts its competitors.

When farmers come in to cut and burn a forest, all the vegetation on the surface is destroyed and few plants can regenerate quickly. But the babassu palm has an unusual feature not shared by most other species—its apical meristem, the part of the plant that is actually growing, is pushed underneath the surface during germination. This adaptation allows most juveniles to survive being cut and burned, even if their aboveground portions are completely destroyed. We had firsthand experience with babassu's extraordinary capacity to regenerate while setting up experiments that required removing all palms from a site. We cut the juvenile palms repeatedly, to no avail. Finally, in frustration, we attempted to eradicate them by driving wooden stakes into their underground palm hearts. But the palms kept regenerating, which forced us to conclude that young babassu are harder to kill than Count Dracula. And once they dominate a site, they are there to stay: at one site that had been cleared thirty-three years earlier, we found that the population of babassu was still increasing. Thus the babassu palm, a strong latent presence in the uncut forest, stands alone in the cleared forest.

For many people living in Maranhão the formation of pure babassu stands has been a blessing. In one rural district of the state, 86 percent of the households use babassu leaves as thatch for their huts. From July to December, the dry season in Maranhão, people scale the palms and remove their leaves, which are often twenty-four feet long. When leaves are harvested every four years, it seems to have little effect on the tree's growth, although fruit pro-

duction drops off the following year. Aside from thatch, people use the leaves to make baskets, rugs, mats for drying grains, fans for tending fires, and sieves for sifting cassava flour and rice. In addition, they make fences, window frames, platforms for herb gardens, birdcages, even fish traps. Hunters use the leaves to make blinds when they are after agoutis, pacas, and porcupines, all of which feed on babassu fruit. Finally, cattle and donkeys feed on the leaves of babassu during dry spells.

The trunks of babassu palms are often used for construction work. People build small bridges and benches out of them. The trunks also attract weevil larvae, which local people fry and eat. People also eat the bruchid beetle larvae that attack babassu seeds. When fried, these larvae taste like bacon and are considered a delicacy. After felling a palm, people sometimes extract its heart and feed it to pigs.

Babassu fruit is also amazingly useful. In the state of Maranhão alone, 300,000 families participate in a cottage industry devoted to extracting the oil-rich kernels from the fruit, which is harvested during the dry season. Since men are usually busy clearing and burning agricultural plots at this time, most of the people who break babassu fruit are women and children.

The kernels extracted from the fruit have many uses in the home. People make babassu "milk" by roasting kernels, then crushing them in a mortar and mixing them with water. This liquid is then strained. The milk—and its mineral composition is similar to that of mother's milk—is fed to infants. To make oil, the kernels are roasted, crushed, and cooked; the oil is then skimmed off the surface. When we surveyed local households in our study area, we found that 54 percent of the people used homemade babassu oil for cooking and soap production. Even the residue from these domestic products has a use: it provides a nutritious feed for pigs and chickens.

The husks from babassu fruit are not thrown away—these dry shells, like everything else about babassu, are a valuable commodity. The husks consist of a fibrous outer layer (the epicarp), a starchy middle

M. J. Balick

An Apinaja Indian woman, below, peels off the starchy mesocarp of babassu fruit. This middle layer is used to make flour. The mat she is sitting on and the basket next to her are made from babassu leaves. At right, local women break the fruit to get at the oil-rich kernels. These seeds are also roasted, crushed, and mixed with water to make a milk substitute.

Randall Hyman

layer (the mesocarp), and a woody inner layer (the endocarp). Livestock eat the mesocarp; people also use it to make flour for cooking. The rest of the husk is made into charcoal. Husks are placed in a shallow pit and burned in a hot fire. As the fire burns, people continue to add more debris and this gradually promotes carbonization. In one district of Maranhão, we found that 96 percent of the homes used babassu charcoal as their exclusive source of fuel. People frequently make charcoal in the evening because the smoke is an effective insect repellent. And in certain areas of the Amazon Basin, the fruit of this all-purpose palm is used to smoke rubber.

Breaking into a babassu palm fruit is no easy task. People place the fruit on top of an upturned ax blade and beat it with a club until it breaks. A fruit breaker has to hit the fruit an average of twenty-six times before it splits, yielding three to five kernels. With this technique, a fruit breaker can get about nine pounds of babassu kernels each day. Most of the kernels are sold to local industries, which use them to produce oil, soap, and feed cake. Prices fluctuate wildly, depending on market conditions and the number of middlemen involved in the sale. But regardless of the price level, a fruit breaker rarely makes more than a dollar a day. Perhaps for this reason, 93 percent of the people who gather and break the fruit of babassu palms belong to the poorest class in Maranhão—the landless.

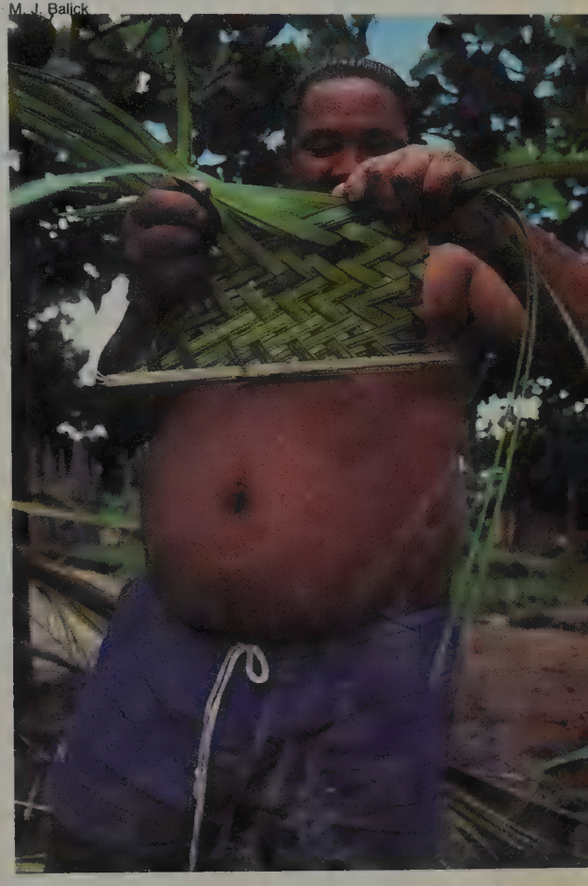
For people who have few economic options, gathering and breaking fruit is sometimes the only way to make a living. Many of the women who work with babassu are widows or are separated from their husbands. They find that the work, while not particularly lucrative, is suitable for other reasons. They can do it after they have finished their housework and taken care of their children. When the children get older, they join their mothers in gathering and breaking fruit. Families ofte stockpile fruit in the home and extra kernels during periods when the fruit ha vest is small. This gives them a mode source of income throughout the year.

For all of these reasons, babassu has b come a contemporary "tree of life" in M ranhão. But the palm has also found i way into the market economy and the ke nels are used in scores of local industrie Until recently, these industries were th largest single source of tax revenues in th state's economy. The oil, which makes u about 70 percent of the kernel weight, similar to coconut oil. The babassu oil i dustry, which has grown rapidly over th past sixty years, is currently the largest its kind entirely dependent on a wild plan

Other industrial products come fro the fruit's husk. Among these are ethano

Although not crucial for survival, palm fans make life more comfortable in the humid tropics. A local craftsman in the area of São Jose weaves one from babassu leaves.

M. J. Balick



nethanol, coke, acetic acid, reactivated harcoal, combustible gases, and tar, vhich taken together have hundreds of industrial applications. For a long time vould-be manufacturers were stymied by he lack of machinery that could efficiently crack the hard fruit. But new machinery has recently been developed, making it possible to exploit a wide range of babassu products on a large scale.

As babassu increasingly becomes industrialized, some hard questions will have to be answered about managing the palm forest. For example, can the forests be managed as they are or should they be replaced by high-yield plantations? How these questions are answered will determine not only the future of the palm's place in the landscape but also the fate of the people who depend on it.

Because it tends to grow in pure stands, babassu is relatively easy to manage. Indeed, people have been managing it for a long time. In the northeastern state of Ceara, now-extinct aboriginal groups probably planted groves of babassu thousands of years ago, using seeds carried from hundreds of miles away. The Kayapó Indians of southern Amazonia plant babassu on shifting cultivation plots and tend them during the fallow period. These stands are often extremely productive, which makes us suspect that the Indians have selected high-yield strains. Ranchers and shifting cultivators frequently remove unproductive palms from the stands and thus have done some selecting themselves.

Not only is babassu easy to manage, but it also seems to have a crucial role in sustaining agriculture. Generally speaking, shifting cultivators will completely clear a forested site and then use the leaves and wood as fuel for a burn. The burn recycles nutrients and controls weeds, essential steps if farmers are to successfully grow their usual crops—rice, corn, beans, and cassava. After one or two years they abandon the site for a fallow period, during which the forest regenerates, eventually allowing another cycle of farming.

But with babassu, farmers never have to actually clear the area they want to plant. This is because babassu stands contain a tremendous amount of fuel in the form of leaves. In one stand, we found that the biomass of living leaves was thirty-one tons per acre. Thus, the leaves themselves provide ample material for a good burn. In a forest dominated by babassu, a shifting cultivator only has to thin the trees moderately, not cut them down. The babassu stand can thus be maintained during the entire agricultural cycle and provide a continual source of support for local people. And because the farmers are cutting leaves, not stems, the forest recovers quickly—producing enough fuel for a new

Anthony Anderson

A babassu palm stand is burned, below, to recycle nutrients and kill weeds, so that crops can be planted. Probably the most important feature of babassu is that it lends itself easily to shifting cultivation. Local farmers plant crops among the palm trees, and after a fallow period, they can use the leaves of the palm as fuel for a new burn and begin another cycle of planting. Thus even while they are farming babassu plantations, shifting cultivators continue to benefit from the wild palm. At right, children help bring in a load of fruit.

Peter May

burn in about four years. Ordinarily, a cleared forest takes seven or eight years to build up sufficient fuel for a burn.

In spite of these attributes, babassu is plagued by a number of serious limitations. First, the palm grows extremely slowly. Even under optimal conditions it takes a dozen years to mature. In addition, yields from the wild stands are low, averaging less than 1,800 pounds of fruit per acre annually. The African oil palm, by comparison, takes four years to mature and can produce 22,000 pounds per acre. Finally, collecting fruit from wild stands of babassu is extremely time consuming, which reduces the palm's competitiveness in both domestic and world markets.

These factors have led some people to suggest that plantations of the palm should be established using genetically improved strains of the plant. Efforts to domesticate babassu this way have already begun, and based upon our own research we believe it would certainly be possible to improve the palm for use in the marketplace.

This approach, however, would ignore the very attributes that make babassu unique. Pure stands of the palm form spontaneously, require little maintenance, and are already used by people. Intensive plantations of babassu would inevitably exclude the landless people now dependent on the plant. We believe babassu's productivity could be improved without introducing intensive, high-technology systems of agriculture and shutting out those who need it.

Some of the palm's limitations could be overcome through better management of existing stands. Selective thinning can enhance yields. Rather than gathering fruit from the ground as they do now, people could be encouraged to harvest fruit from the crowns. This would reduce losses. And if superior strains were developed, they could be planted in pastures or fallow areas or even in degraded sites in the Amazon Basin. Finally, if the current technology that has been developed for processing fruit could be adapted for use by local people, they could produce subsistence products much more efficiently and possibly sell the excess to distributors.

These suggestions might seem unconventional when compared with the standard approach that developers take in the Third World—which usually involves a complete transformation of the land and its native vegetation. But the current breakdown in land uses throughout the humid tropics calls for radical changes in the way agriculture is practiced. In places that are undergoing rapid settlement, the trick is not to maximize agricultural output but simply to maintain it. Stands of wild babassu palm, an extraordinary subsidy from nature, represent one solution to this problem. □

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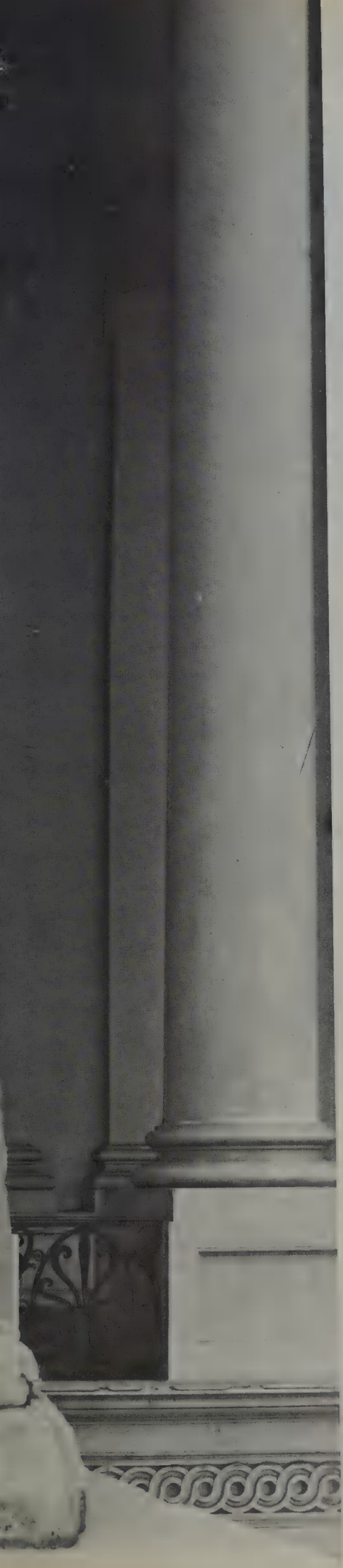


Horatio Greenough's sculpture The Rescue *stood on the east portico of the U. S. Capitol from 1853 to 1958. By contrasting the roles of male and female, red and white, the sculptor celebrated the triumph of "civilization" over "savagery," but distorted the reality of captivity in frontier times.*

Architect of the Capitol

Captive Images

Stereotypes that justified colonial expansion on the American frontier were a legacy of a seventeenth-century war

by Pauline Turner Strong

As the white woman, baby clutched to her breast, cowers below, a towering frontiersman overpowers a tomahawk-wielding Indian. Entitled *The Rescue*, this marble sculpture by Horatio Greenough was commissioned by the United States Congress and installed in 1853 at the eastern entrance to the Capitol. Adapting classical forms to an American theme—the frontiersman is draped and helmeted—Greenough sought to create an image, as he wrote to the secretary of state, that commemorated "the triumph of the whites over the savage tribes, at the same time that it illustrates the dangers of peopling the country." He also intended that the sculpture serve as "a memorial of the Indian race, and an embodying of the Indian character."

As substantiated by its scale, execution, and placement, the monument does not depict the rescue of any particular mother and child. The marble figures embody mythic archetypes: the vulnerable white victims, the brutal Indian aggressor, the heroic male redeemer. The raised hatchet demonstrates the Indian's ferocious character: savagery threatens to dominate civilization by wrenching its weak and fledgling members from an orderly, protective environment and holding them hostage in the wilderness. This threat justifies not only the act of rescue but, ultimately, white expansion at Indian expense.

The iconography of *The Rescue* was a legacy of the late seventeenth century, a time when the New England colonies and the surrounding Algonquian-speaking peoples were embroiled in unprecedented violence. The height of conflict, from June 1675 to August 1676, was known to the English as King Philip's War, for Philip was the name the English gave their foremost adversary, Metacomet. Philip was the sachem, or leader, of Pokanoket (present-day Bristol, Rhode Island), the largest village in the Wampanoag alliance, one of several Algonquian groups in southern New England. During the war, Philip's forces captured some forty adults and children from frontier settlements. One, a clergyman's wife, wrote a remarkable account of her experience, published in 1682 as *The Sovereignty and Goodness of God, Together, with the Faithfulness of His Promises Displayed; Being a Narrative of the Captivity and Restoration of Mrs. Mary Rowlandson.*

Among the foremost popular works of its century, Mary Rowlandson's narrative initiated an iconography of captivity that eventually reduced complex colonial frontier history to the relationship between a white female captive and a red male captor. Ironically, however, Rowlandson's primary antagonist was not a man, but a powerful woman. And Rowlandson's sufferings and those of her compatriots pale in comparison to the devastation several thousand red captives suffered at the hands of the English.

Mary Rowlandson left a vivid and detailed record of her twelve weeks of captivity because, as a devout Puritan, she considered the most mundane occurrences to be signs of the will of God. Her observations are especially significant historically because the Algonquians, recognizing that a clergyman's wife was an exceptional prize, strategically placed her in the care of one of their major leaders, the Narragansett sachem, Quanopin.

Mary Rowlandson thought highly of her "master," Quanopin, calling him "the best friend that I had of an Indian both in cold and in hunger," but she despised his

The Newberry Library

wife Wetamo. A "severe and proud dame," Wetamo seemed to delight in playing upon her captive's anxieties and arbitrarily depriving her of food, fire, shelter, and the solace of the Bible. Although Mary Rowlandson realized that Quanopin was a sachem and learned that Wetamo's sister was Philip's wife, she was unaware that her "mistress" was, in her own right, the sachem of the Wampanoag village of Pocasset (on the modern sites of Fall River, Massachusetts, and Tiverton, Rhode Island).

Wetamo was one of several female sachems who came into prominence during King Philip's War. "Squaw sachems," as the English called them (using the Algonquian term for woman), could attain authority as the widows of sachems; Wetamo, however, like a male sachem, achieved leadership through descent within a ruling patrilineage. Whether male or female, the Algonquian sachems governed their villages through persuasion, regulating internal matters such as the production of food, the distribution of resources, and the resolution of disputes. Sachems also established alliances with other villages through diplomacy, trade, tribute, and marriage. During times of hostility, leadership might pass to a separate authority with demonstrated proficiency in warfare, but sachems could be influential in war as well as in peace; this was the case with Wetamo, whose warriors reportedly numbered three hundred at the outbreak of the war, arousing great fear among the English colonial settlers.

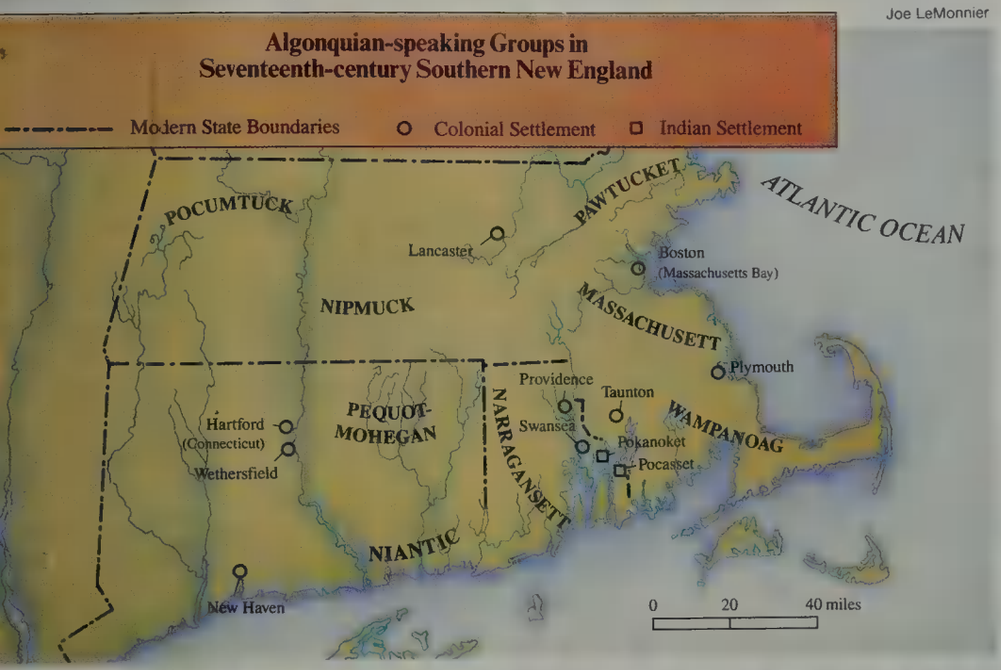
Wetamo, like Quanopin, was drawn into King Philip's War through a series of events that preceded the conflict. Philip's father, Massasoit, had signed a treaty of friendship with the Pilgrims in 1621, shortly after their landing at Plymouth. To the Wampanoags, recently decimated by a European-borne epidemic, the new colonists represented valuable support against their enemies to the west, the Narragansetts. The Pilgrims, in turn, perceived the alliance as a protectorate allowing them to establish a claim over Wampanoag land (although Massasoit insisted on his right to sell land to other colonies). The alliance survived until Massasoit's death in 1662, preserving the Wampanoags from the fate of the Pequots and Narragansetts, who suffered ruthless colonial attacks in 1637 and 1643, respectively.

The alliance became particularly significant to the Pilgrims after the Restoration of 1660, when Plymouth had to defend its land claims before Charles II in the face of competing claims from the Massachusetts Bay, Connecticut, New Haven, and Providence colonies, all established in the sixteen thirties and forties. Plymouth pressured Massasoit's son and successor, Wamsutta (Alexander, to the English) to sell land only to Plymouth. Indeed, in 1664, after Alexander had initiated independent land dealings with Providence, he was seized at gunpoint and forced to march to Plymouth to answer for his actions. Already ill, Alexander died after this episode and was succeeded by his brother Philip. Alexander's widow was none other than the "squaw sachem of Pocasset," who took the name Wetamo to mark her change in marital status. Philip married Wetamo's sister, thus preserving the alliance between the towns of Pokanoket and Pocasset.

Relations with Plymouth worsened during Philip's tenure as sachem, as Plymouth encroached on Philip's authority, as well as on his people's land. In 1667 Plymouth established a new town, Swansea, on land claimed by both Philip and Provi-

here are no authentic portraits of the Algonquian leader Metacomet, or Philip, the dian protagonist in what the colonists called King Philip's War. Paul Revere's oodcut of Philip, left, published in 1772, was based on a famous 1710 painting of a ohawk. The map below shows the locations of the major Algonquian groups in uthern New England at the time of King Philip's War (1675–1676). Important ttlements that featured in the war's history are also shown. The woodcut, bottom, is om the 1791 edition of Mary Rowlandson's narrative of her captivity by the Indians ring King Philip's War. It depicts the attack on Lancaster, Massachusetts, during hich she was taken hostage.

Joe LeMonnier



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dence. Philip protested, only to see Swansea expand. Four years later, after Wampanoag men brandished weapons near Swansea, Philip was forced to sign a treaty acknowledging subjugation to colonial authority. This marked a significant loss of independence for the Wampanoags, who had considered themselves subject only to the king of England. Rumors of an Indian conspiracy against the colonists had surfaced periodically since Alexander's brief tenure, and more than a decade of mounting tension finally climaxed in 1675, when a Christian Indian who had accused Philip of conspiracy was murdered. By June, Plymouth had declared war on Philip and fighting began in the troublesome Swansea area.

Wetamo, who controlled nearby lands that several of the colonies desired, allied herself with Philip early in the war, parting with her husband, who maintained his allegiance to the English. She supplied provisions and forces for Philip's campaign, and at the end of June, Philip fled from his territory to hers, where together their peoples hid in the Pocasset cedar swamp. Driven out at the end of July, Philip headed north to seek an alliance with the Nipmuck, while Wetamo and her people took refuge to the west among the Narragansetts. There she became Quanopin's third wife, sealing an alliance between their peoples.

Although the Narragansetts had been enemies of the Wampanoags, the refugees could expect they would be adopted and furnished with houses, goods, and fields. Such was the indigenous pattern of warfare: while certain captives, generally the warriors, might be tortured and executed and others might be held for ransom, a displaced population was commonly adopted. Each of these alternatives was a way of compensating those who had lost relatives in war.

In July 1675, the English managed to get four powerless Narragansetts to promise that the Wampanoag refugees would be handed over. The legitimate leaders stalled; although eager to maintain neutrality, they knew from past experience that refugees could expect harsh treatment from the colonists. After the con-

Popular, cheap, and readily available, dime novels were first marketed in 1859. Novels such as The Long Trail, *below, sensationalized and spread stories of capture by Indians. The theme of rescue, which illustrates* Simple Phil, *opposite page, echoes Greenough's sculpture by casting the white woman as victim, the frontiersman as hero, and the Indian as depraved villain.*

Rare Book Division, The New York Public Library

quest of the Pequots in 1637, the Narragansetts had seen the several hundred Pequot survivors of a horrifying slaughter driven from their lands and consigned to slavery in the colonies, among Indian allies of the English or, in the case of at least fifteen boys and two women, in the West Indies. For five months the English pressed the Narragansetts to return the Wampanoag refugees, all the while confirming the Narragansetts' worst fears by selling several hundred Algonquians to slave traders heading for Spain and the Azores and retaining another hundred as domestic slaves. The majority of these unfortunates were at peace when they were captured or had voluntarily submitted themselves to colonial authority.

In December 1675, using the Narragansetts' protection of the Wampanoags as a pretext to conquer land they had long coveted, the United Colonies of Plymouth, Massachusetts Bay, and Connecticut (which now encompassed New Haven) joined in a massive attack on the Narragansetts' major swamplands stronghold, killing from three hundred to six hundred men, women, and children. (Dissident Providence—allied to the Narragansetts and excluded from the United Colonies—was not involved in the attack.) This, the Great Swamp Fight, forced the majority of the Narragansetts into the hostilities. Quanopin took a leading role in a series of offensive strikes against frontier towns. The first of these, an attack in mid-February on Lancaster, Massachusetts, was the one in which Mary Rowlandson was captured, along with three of her children and as many as twenty neighbors.

Mary Rowlandson's suffering during captivity was profound: she witnessed the deaths of her wounded six-year-old daughter, her sister, and a number of her neighbors; she was separated from her husband and her other children; she withstood the cold, hunger, and grueling travel that were the lot of her displaced captors; and she endured the hostility and torments of a besieged squaw sachem. Her ability to convey these experiences in simple and vivid prose contributed to the enduring popularity of her narrative, which has gone through forty editions and numerous anthologies in the three centuries since its publication. But her success in achieving publication (she was only the second woman to do so in New England) and initiating an influential ideology of captivity was especially tied to her penchant for interpreting the entire affair as an example of "the strange providence of God" toward his chosen people.

In her narrative, Mary Rowlandson

Rare Book Division, The New York Public Library

ays no attention to her captors' griev-nces or to possible motivations for their ctions, whether abusive or merciful. In-tead she presents her captors as instru-nents of Providence intended to provide ier with a spiritual trial and an opportu-nity for redemption. The numerous kindnesses of Quanopin, Philip, and oth-ers, as well as the complete lack of sexual harassment, are, to Mary Rowlandson, ev-dence that God was restraining the Indi-ans' innate depravity. Conversely, she sees he taunts and deprivations she suffered at he hands of Wetamo as confirmations of hat depravity—indeed, as signs of Weta-mo's subservience to that diabolical mas-ter, Satan.

In reality, the disparity between Quano-pin's and Wetamo's treatment of Mary Rowlandson had a more mundane basis. Apparently the couple disagreed as to the value of their captive, with each following an alternative cultural pattern. Quanopin was primarily interested in using Mary Rowlandson as a bargaining chip, while Wetamo assumed a role (common to fe-male lineage heads among northeastern Indians) of abusing her captive as a way of compensating herself and her lineage for heavy wartime losses.

Wetamo's hostile stance was no doubt exacerbated by Mary Rowlandson's fail-ure to recognize Wetamo's status and her refusal to defer to her mistress as readily as she did to her master. The product of a patriarchal society, Mary Rowlandson in-terpreted Wetamo's authoritative stance as vanity and insolence. She openly dis-obeyed her orders—refusing, for exam-ple, to hand over a piece of her apron for use as a child's loincloth—and was critical of her for "bestowing every day in dressing herself near as much time as any of the gentry of the land."

In April 1676, about two months after the attack on Lancaster, two Christian Al-gonquian intermediaries were sent to Phil-ip's camp to negotiate for the release of the English captives. When they arrived, "though they were Indians," Mary Rowlandson "got them by the hand and burst out into tears," inquiring after her husband and friends. Early in May, after three rounds of negotiations, Mary Rowlandson was returned to the English in exchange for a ransom payment. Her fourteen-year-old son and ten-year-old daughter, along with about twenty other English captives, were ransomed during the summer. Their home and village hav-ing been destroyed, the reunited Rowlandson family lodged with friends until, in the spring of 1677, the Reverend Mr. Rowlandson received a new pulpit in Wethersfield, Connecticut.

In contrast, the months after Mary Rowlandson's ransom were disastrous ones for Philip and his relatives. The ma-jor Narragansett leader, Quanopin's cousin, was captured and killed early in April by Indian allies of the English. Quanopin took over the leading role in June, but was captured in mid-July, and the following month he was court-martialed and shot for treason against the king of England. Wetamo and her three dozen remaining followers were am-bushed while trying to return to their home at Pocasset. As the tale was told by Rev. Increase Mather:

> Only the *Squaw-Sachem of Pocasset*, who was next unto *Philip* in respect of the mis-chief that hath been done, and the blood that hath been shed in this Warr, escaped

Wadsworth Atheneum, Hartford

The Death of Jane McCrae *was painted by American artist John Vanderlyn in 1804. The artist used conventional imagery, such as the upraised tomahawk and highlighted contrasts in sexuality and ethnicity.*

alone; but not long after some of *Taunton* finding an Indian Squaw in *Metapoiset* newly dead, cut off her head, and it happned to be *Weetamoo,* i.e. *Squaw-Sachem* her *head.* When it was set upon a pole in *Taunton,* the Indians who were prisoners there, knew it presently, and made a most horrible and diabolical Lamentation, crying out that it was their Queens head. Now here it is to be observed, that God himself by his own hand, brought this enemy to destruction. For in that place, where the last year, she furnished *Philip* with Canooes for his men, she her self could not meet with a Canoo, but venturing over the River upon a Raft, that brake under her, so that she was drowned, just before the English found her. Surely *Philips* turn will be next.

In his prophecy, at least, the gloating Mather was correct: within the week, Philip was killed by an ally of the English from Wetamo's town of Pocasset. The commander of the English forces ordered Philip's body to be drawn and quartered, the head being sent to Plymouth, where it was displayed on a pole for more than twenty years. Philip's wife (Wetamo's sister) was sent into slavery in the West Indies, as was their young son, a decision made after considerable debate among the Puritan clerics, some of whom cited scriptural precedents in recommending that the boy receive the punishment of execution for his father's treason.

Numerous other Algonquian leaders and warriors were executed in August and September, and armed resistance soon ended. The colonies moved to recoup the heavy costs of the war, first, by appropriating Algonquian lands and, second, by selling captives in West Indian or European slave markets. The enslaved Algonquians included about four hundred who surrendered near the end of the war with the expectation of leniency; still other captives were sold to colonists as indentured servants. The remaining New England Algonquians either fled to Canada or were settled on small reservations. As costly as the war had been for the English—about six hundred colonists died, some forty more were captured, and perhaps twenty frontier towns were destroyed—the price pales in comparison with the Algonquian losses: three to five thousand people were killed or captured, at least a thousand were enslaved, and the few who remained at liberty were deprived of their fertile homelands and dispersed.

To the victors belonged not only the spoils but also the symbols of the war. Captivity became the primary metaphor for conveying the tragedy of King Philip's War, but the hundreds of Algonquian captives, such as Philip's wife and son—who were indentured or sold into slavery—were forgotten. Rather, it was the ordeal of Mary Rowlandson that came to epitomize the meaning of the war and, by extension, to legitimize all violence against Indians. As a vulnerable gentlewoman in the hands of a ferocious heathen, Mary Rowlandson personified the settlers' fear that colonial "civility" and "godliness" would be overcome by the "savagery" of the American wilderness and its native inhabitants.

In the years following the publication of the Rowlandson narrative, the theme of captivity became a conventional way to contrast white civilization with Indian barbarism. Narratives describing actual and fictional captivity became a popular and distinctively American genre, which was realized in visual form in drawings, paintings, and sculpture. As the frontier moved westward there were significant variations upon the theme: tales took on a secular character and sometimes featured a heroic rescuer, a male captive, or even an acculturated captive. The most typical, however, resembled Greenough's sculpture, taking their power from contrasting a white female captive to an Indian male captor.

The complexity of captivity on the frontier—where Indians, too, were captives and the captors included women such as Wetamo—was reduced to stereotypes that sharply divide civility and savagery, aggression and vulnerability, along the lines of ethnicity and gender. *The Rescue,* a prominent example of this deceptive iconography, was removed from the United States Capitol in 1958, but similar images remain enshrined in other public monuments, as well as in the folklore, drama, art, and literature of popular American culture. □

upper side

Tyrse Argus, Gray Western Africa.

Brought home, alive, by Mr Whitfield

The Original of the figure in the 'Gleanings'.

All photographs by Coxe/Goldberg Photography, Inc.

Private Collection

The Sense and Nonsense of Edward Lear

est known for his limericks and verse, Lear was also a versatile portrayer of natural and unnatural history

y Vivien Noakes

Edward Lear was described by one of his contemporaries as a man of versatile and original genius." He was an rnithological draftsman, compared in his own time with udubon; a superb landscape artist; a traveler and musician; nd the creator of a genre of children's writing in which, as lonsense poet, he stands supreme.

It is not only his versatility that is extraordinary but also his roductivity. When Lear died he left at least seven thousand atercolors made on his travels; about two thousand studio atercolors, including the sets of illustrations to Tennyson's oems; more than three hundred oil paintings, which vary in size rom six inches to fifteen feet; two books of natural history lustrations; more than a hundred additional published rnithological lithographs; six travel books and five or six travel anuscripts prepared for publication; four books of Nonsense; a ozen published songs; extensive diaries; and several thousand elightful letters.

Born in 1812, the twentieth of twenty-one children, Lear was rought up by his sister Ann. He began to earn his living at the ge of sixteen, making "uncommon queer shop-sketches—elling them for prices varying from ninepence to four shillings: olouring prints, screens, fans; awhile making morbid disease rawings for hospitals and certain doctors of physic." In 1828 or 829 he became an ornithological draftsman, publishing his first ook, *Illustrations of the Family of Psittacidae, or Parrots,* when he was nineteen years old. The format of this book, and

Excerpted from *Edward Lear 1812–1888* © Royal Academy of Arts 1985

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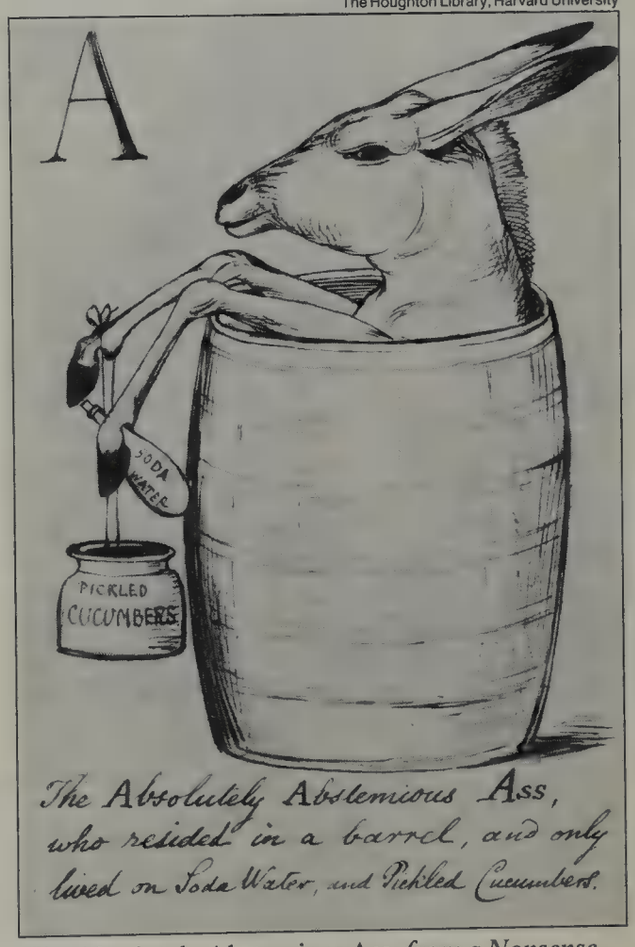

The Absolutely Abstemious Ass, *from a Nonsense alphabet, 1870*

Tyrse Argus *(Eyed Tyrse), from* Gleanings From the Menagerie and Aviary at Knowsley Hall, *1846*

Private Collection

Strix perspicillata *(Spectacled Owl), 1836*

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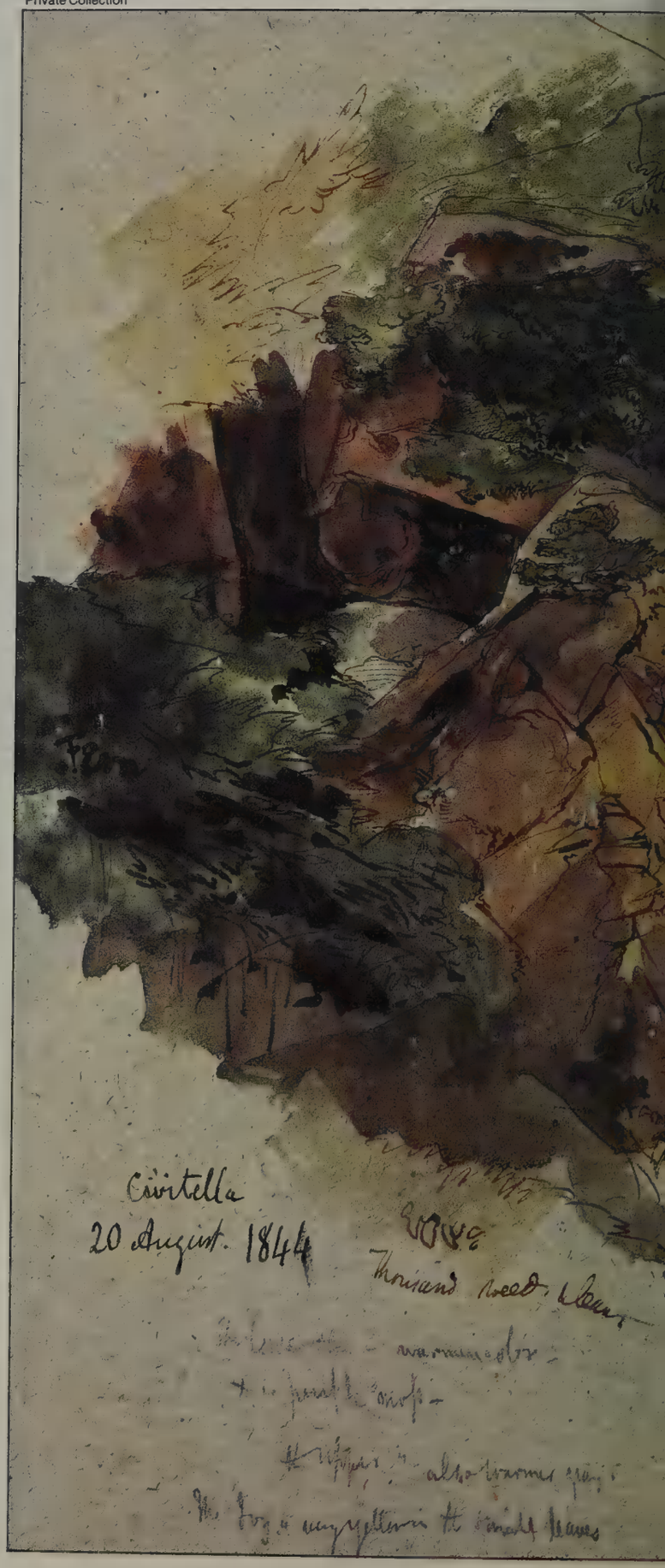


Lear's bold style of drawing, set a new pattern of ornithological work that was to be followed with great success by others, particularly John Gould. Perhaps the most important part of his contribution was his insistence on drawing from living birds rather than from stuffed skins. This made his task difficult but resulted in more truthful representations, both anatomically and in the characteristics of the birds he portrayed. In 1831 Lear was invited by Lord Stanley, heir to the earl of Derby, to make drawings of the animals and birds in his menagerie at Knowsley Hall, just outside Liverpool. There Lear mixed with "half the fine people of the day," establishing a network of patronage on which he was to depend for the rest of his life.

By the time he was twenty-five he had abandoned his ornithological career to become a landscape painter. His next ten years were spent in Rome, a city that at the time attracted artists from all over Europe, with an English community that was prepared to buy and commission paintings. During these Roman years, between 1837 and 1848, Lear progressed steadily and found a ready market for his work. He returned to England twice—in 1841 and 1845–6. In 1841 he published a book of lithographs, *Views in Rome and its Environs,* and in 1846 his first travel book, *Illustrated Excursions in Italy,* appeared. In 1849 he returned to England, where he planned to settle permanently.

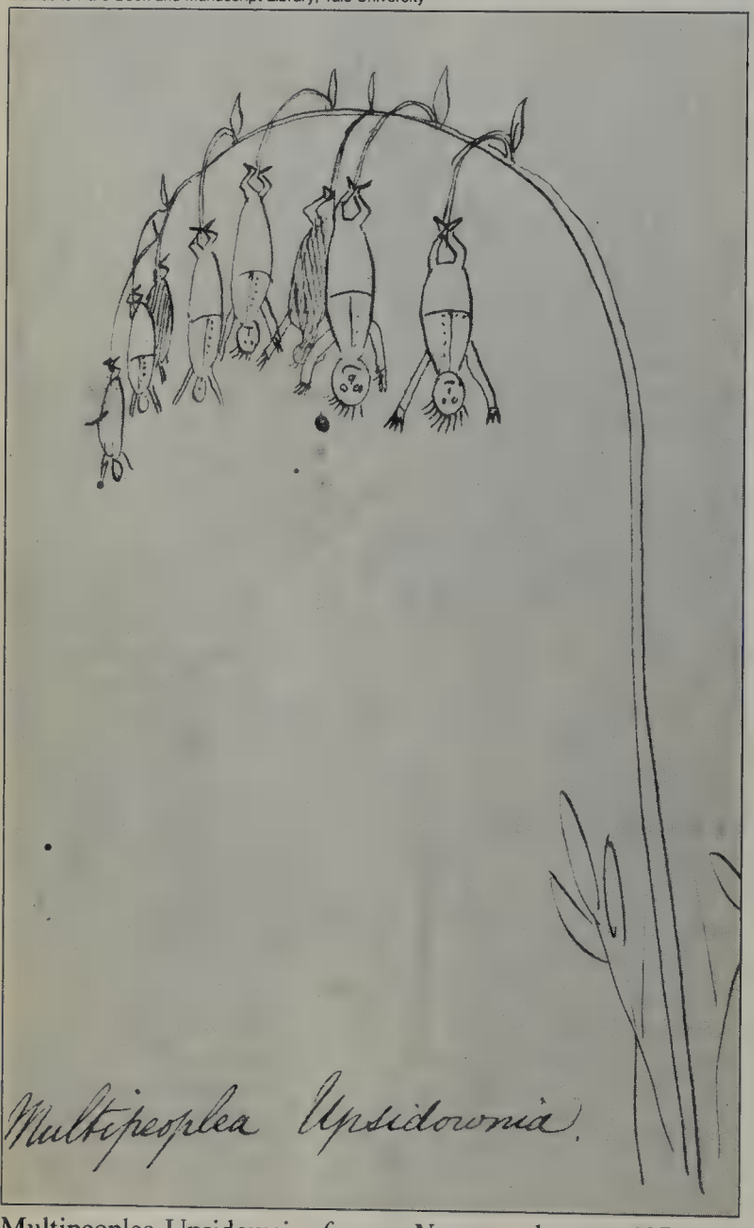
Lear's strength lay particularly in two areas of draftsmanship: in his ornithological work and in the best of the many thousands of landscape drawings made on his travels. Lear himself said, "I am certain, whatever good I may get by 'colour from nature' I get more by pencil," and it was in his drawing rather than in his use of paint that he built up form. This can be seen most clearly in his travel drawings, but these works were not offered for sale. Lear regarded them as his working capital, the basis of his oil paintings and what he described as his finished watercolors.

As for his work in Nonsense, Lear wrote that it "is the breath of my nostrils." It was inseparable from his life and expresses both his merriment and his most deeply held beliefs.

Lear was a man of courage not only in his travels through remote and difficult countryside but more particularly in his constant struggle to overcome the constraints imposed upon him by epilepsy, with the isolation and loneliness it brought. "Alas! Alas! how fearful a birthright was mine," he wrote in the last

Italian landscape, 1844

Beinecke Rare Book and Manuscript Library, Yale University



Multipeoplea Upsidownia, *from a Nonsense botany, 1870*

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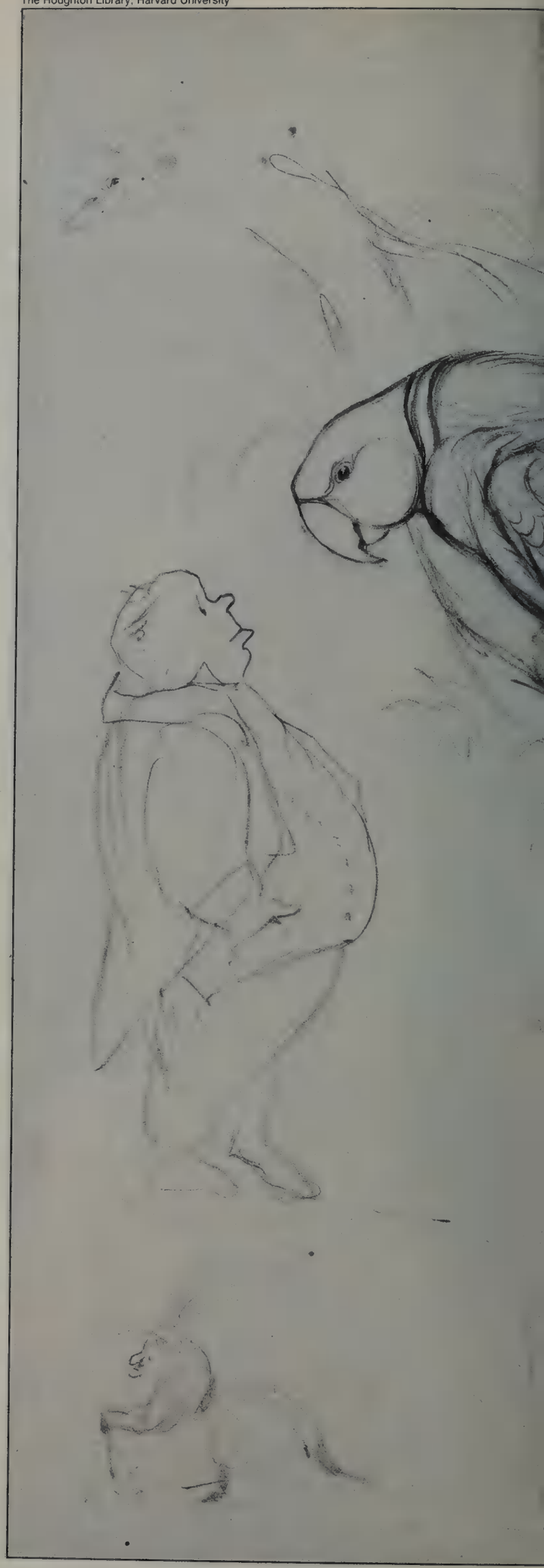

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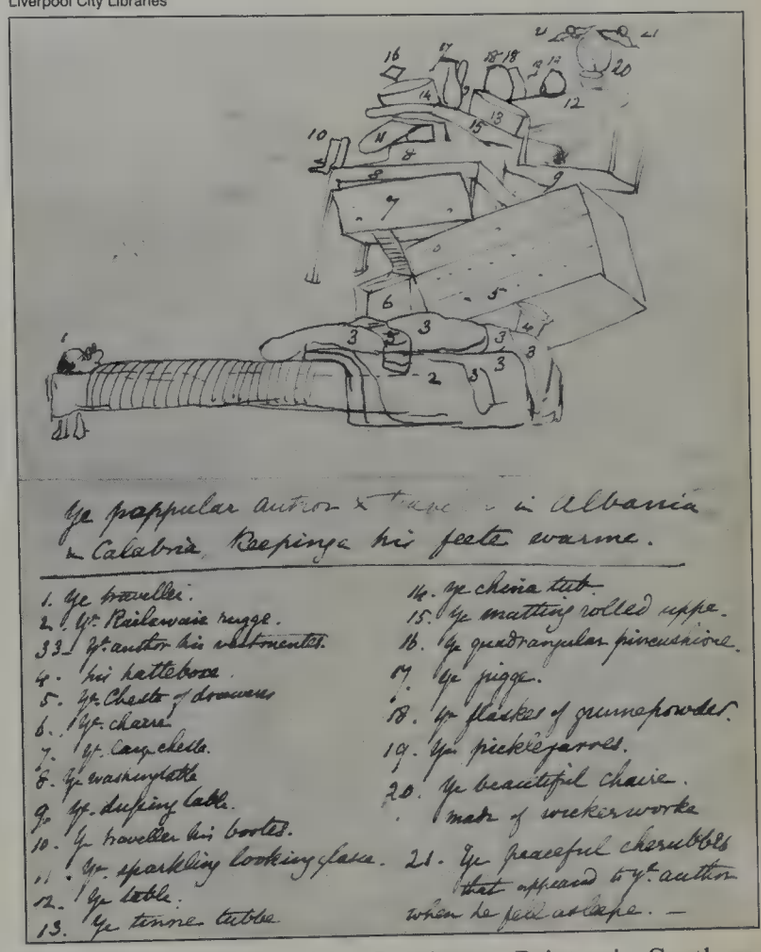
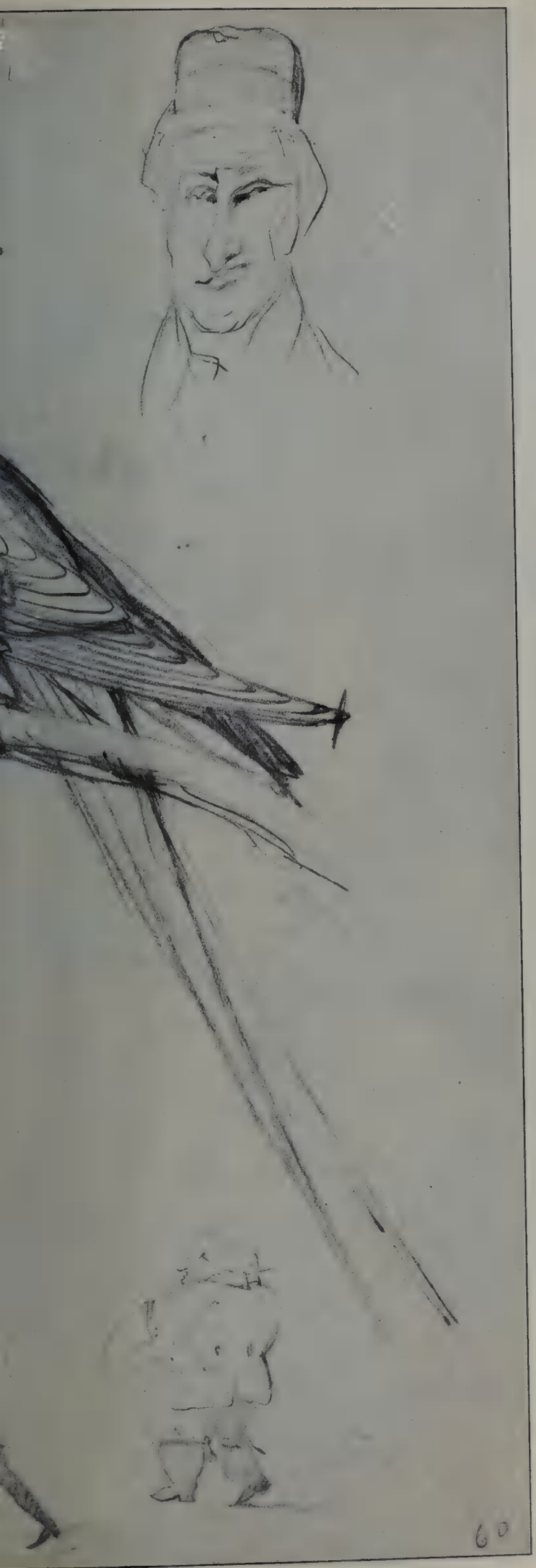

Ye poppular author & Trave... in Albania
& Calabria, Raepinge his feete warme.
1. Ye traveller.
2. Ye Railewaie rugge.
3. Ye auctor his instrumentes.
4. his hatteboxe.
5. Ye Chests of drawers
6. Ye chaire
7. Ye Camp chests.
8. Ye washingstelle
9. Ye dineing table.
10. Ye traveller his bootes.
11. Ye sparkling looking glasse.
12. Ye table.
13. Ye tinne tubbe
14. Ye chaire tub
15. Ye matting rolled uppe.
16. Ye quadrangular pincushione.
17. Ye pigge.
18. Ye flaskes of gruneepowder.
19. Ye pickle jarres.
20. Ye beautiful chaire.
made of wreckerworke
21. Ye peaceful cherubbes
that appeared to Ye auctor
when he feel asleape. —

Sketch from Journals Of a Landscape Painter in Southern Calabria, *1852*



Unidentified Parrot, from a preliminary study for Illustrations of The Family of Psittacidae, or Parrots, *1830–32*

Private Collection

ır of his life. "I wonder if others suffer similarly? Yet I dare
ask or endeavour to know." Living at a time when sufferers
m epilepsy were still considered social outcasts, Lear told no
e of his disease.

Lear's first epileptic attack came when he was five or six.
ɔm the age of seven he also suffered bouts of acute depression.
he earliest of all the morbidnesses I can recollect must have
en about 1819—when my Father took me to a field near
ghgate, where was a rural performance of gymnastic clowns
and a band. The music was good,—at least it attracted
:—and the sunset and twilight I remember as if yesterday.
ıd I can recollect crying half the night after all the small
iety broke up—and also suffering for days at the memory of
e past scene." It was some years before Lear discovered a way
which he could re-create this clownish gaiety himself; he did
through his Nonsense, and in particular his limericks.

Understanding the constraints of his epilepsy, Lear observed
ıer forces in Victorian society that destroyed the fullness of
ing. The most pervasive of these, one whose influence spread
ɔward through society as the century progressed, was the
angelical church of the time, with its inordinate emphasis on
ı and damnation. To strict evangelical Christians, life
esented many dangers. If they wished to achieve salvation—
ıd the alternative was too terrible to contemplate—they must
ny those aspects of their humanity that were sent to beguile
em back into their essential sinfulness. The human will, a
monstration of pride, must be broken. The body, the
ıremitting occasion for sin, must be curbed of all excess; the
easures of food and dress, of song and dance, laughter and play
ere vanities of the world that must be denied. Such denial
egan in earliest childhood, when joy was synonymous with
vity, and merriment was a step along the broad road to
estruction.

From this anxious narrowness, where hypocrisy might parade
virtue, there could grow a harsh intolerance. For Lear, aware
ways of his own shortcomings, human failures were less to be
ɔndemned than to be understood. His ideal of Christianity was
ı plain worship of God, and perpetual endeavour at progress."
When will it please God to knock Religion on the head and
ıbstitute charity, love and common sense?" he asked. In a
orld of distorted values he longed to see hypocrisy replaced by

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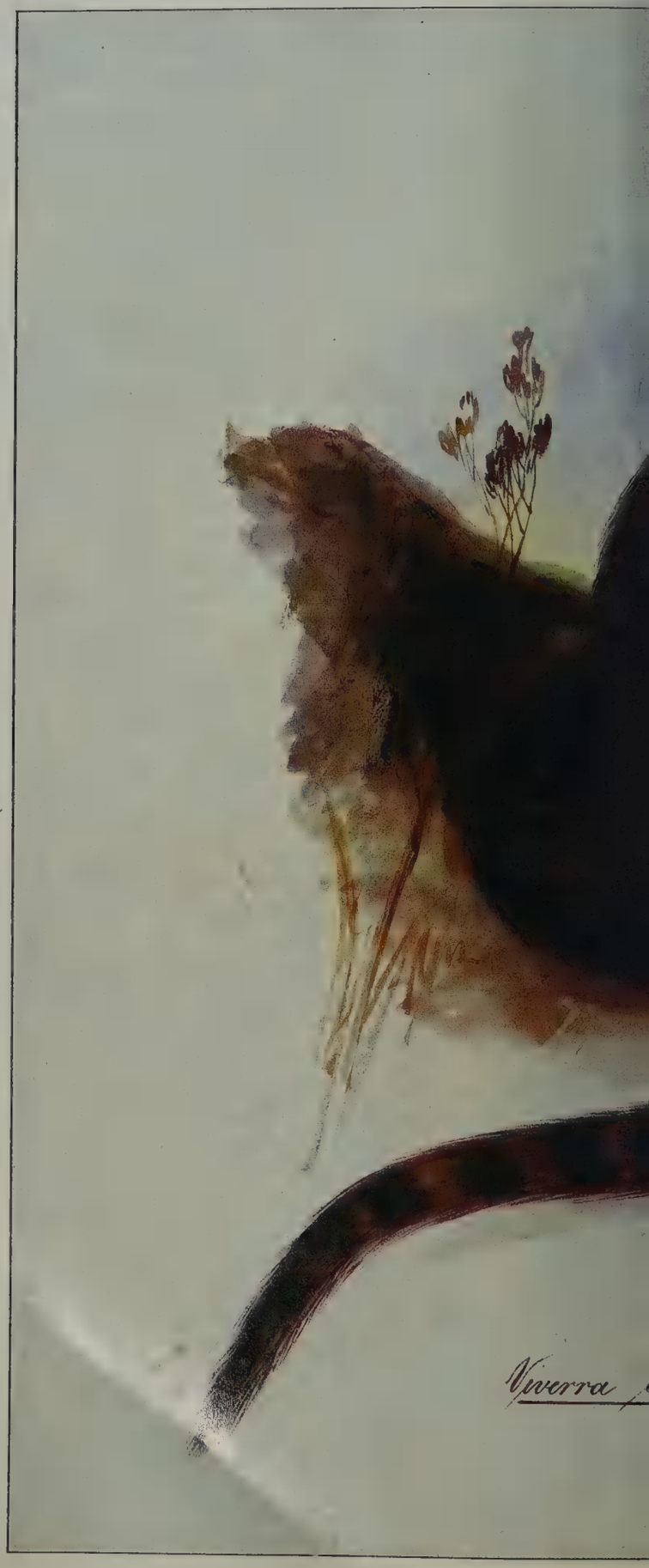
Colored Birds, 1880

Palaeornis melanorhynchus *(? Parakeet), 1835*

honesty, intolerance by charity, ostentation by simplicity, misery by merriment. "My dear child, I'm sure we shall be allowed to laugh in Heaven!" he reassured a small girl.

In his limericks, Lear offered children, to an extent difficult for us now to imagine, the liberation of unaffected high spirits. With a simplicity endorsed by a drawing, the short verse sets the scene and tells the story. The whole—the verse and the drawing—constitutes a clownish act, and the two parts are inseparable. Here are grown-ups doing silly things, the kind of things grown-ups never do. They jump and leap and spin, unabashed both by their unseemly abandon and the sheer folly of what they are doing. They play on crude, rustic instruments and dance hornpipes and jigs, they dress in huge bonnets and wigs, they eat and drink vastly, they are immense and immoderate, strange and impulsive. The limericks do not deceive but share with the children the reality of the human characteristics they display; for all their incongruity, the limericks have a truth that is lacking in the improving literature of the time. In an age when children were loaded with shame, Lear attempted to free them from it. By facing both the good and the bad without criticism, he gave them an opportunity to come affectionately to terms with both themselves and other people.

In Lear's Nonsense songs, the message of tolerance and understanding was joined by another: the excitement of opening one's eyes and exploring the world around, of discovering undreamed-of lands and wonders not only unseen but scarcely even imagined. For Lear, travel was more than a search for paintable views, important though that was. Brought up as a sickly child, he faced hardships in often harsh and unwelcoming countries that drew forth unknown abilities and powers. The strange, more primitive ways of life he observed, and the magnificent grandeur of many remote places scarcely ever visited by foreigners, made him realize the rewards that might come from taking adventurous risks. In a process of self-discovery, which greater caution would have made impossible, he demonstrated to himself that his life need not be ruled by his epilepsy; he saw that, for all its suffering, the world was full of beauty and wonder. Above all, he found in these journeys a physical and spiritual freedom he had never imagined possible and which he sought to share in his Nonsense songs.



Viverra Binotata *(Civet), 1836*.

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Hoard from the Golden Mound

by Walter A. Fairservis, Jr.

The death of Alexander of Macedon in 323 B.C. precipitated the dissolution of an empire that stretched from the Mediterranean Sea to the Indus River. Bactria, a province of that empire, then became an independent state ruled by the Greek and Macedonian descendants of the garrisons left there on Alexander's trek to India. This Bactrian state (now encompassed by a portion of Soviet central Asia and the western part of northern Afghanistan) survived into the first century B.C. Control of Bactria then passed to a number of other peoples. Chief among these rulers were the Kushans, central Asian pastoral nomads who invaded India from bases in Bactria and elsewhere. The Kushans were dominant in central Asia at the same time the Roman Empire reached its height in the West.

For centuries Bactria lay athwart many of the trade routes critical to the commerce of Asia. Indeed, no other area of Asia has been exposed to as many different cultural influences, coming from so many directions. Later Bactrian Greeks were Buddhists, for example, and the fall of their state was due in part to Parthian Persians and central Asian nomads. The Kushans were descendants of the Yüeh-Chi, a pastoral group in close contact with the Han Chinese.

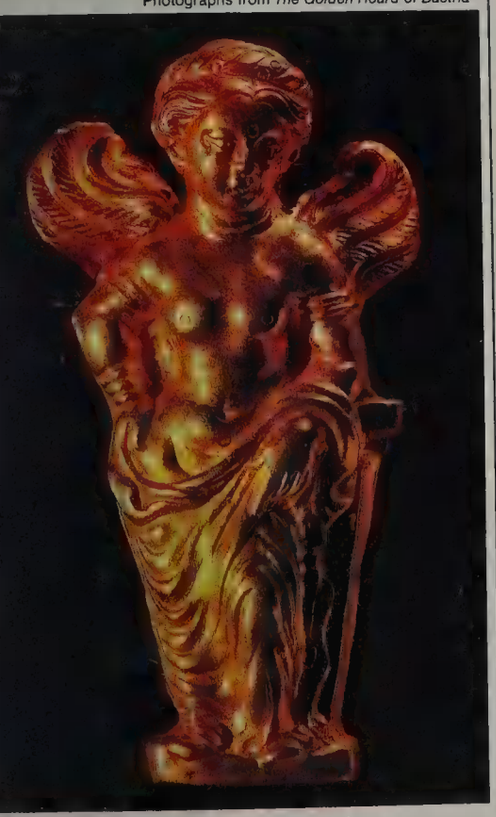
Because the history of post-Alexandrian events in this remote area is sketchy—based as it is on passing references in ancient texts, coins, and legends—archeological research in Bactria is especially important. French, British, Italian, and American missions have from time to time conducted research in Bactria. But because some Bactrian sites are in their country and others are in Afghan areas controlled by their armed forces, Soviet archeologists have been able to conduct the season-to-season digs necessary for substantial results—producing perhaps the only silver lining after five dark years of warfare in Afghanistan. Numerous reports on Soviet archeology in Bactriana have been published, but mainly in Russian journals inaccessible to the general public in the West. This present volume is therefore all the more welcome.

In 1969, a Soviet team headed by Victor Sarianidi—an exuberant, conscientious archeologist well known for his work

Gold figurine of an ibex

THE GOLDEN HOARD OF BACTRIA, by Victor Sarianidi. *Harry N. Abrams, Inc. $49.50; 259 pp., illus.*

Photographs from *The Golden Hoard of Bactria*



"Bactrian Aphrodite" in gold

on numerous sites in Soviet central Asia—came upon a low mound known locally as Tillya Tepe in the vicinity of the city of Shibarghan. The northern Afghanistan plain is strewn with such mounds, most of them dating from late periods in the history of Bactriana. Tillya Tepe, however, had surface remains indicating earlier dates—as early indeed as the first millennium B.C. Unable to begin work at the site, the Soviet team waited until the following season only to find on their return that much of Tillya Tepe was being destroyed to provide earthen material for a new highway nearby. Their protests saved about one half of the site, but archeological work did not begin until 1978. The results have been astounding.

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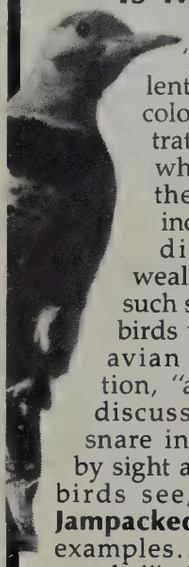

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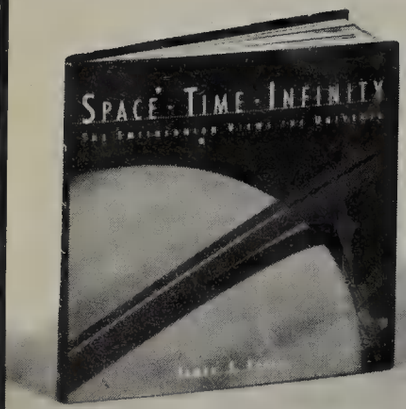

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PANTHEON

Bracelets with antelope design

Six burials dating approximately from the first century A.D., the zenith of Kushan power in these regions, were found in the ruins of a fortified temple of an earlier origin. The excavators speculate that the burials, five of them of women, were of the nobility of the nearby ancient city of Yemshi, perhaps even of the rulers of that Kushan city. The graves were vertical shafts with lidless wooden coffins set at the bottom, most of which were wrapped in clot shrouds decorated with hundreds of gol and silver disks. The graves were the boarded over and dirt was shoveled on top leaving no trace of what was beneath Eventually the board covers collapsed crushing the mortuary contents below Careful excavation, however, revealed treasure trove of the art of the heirs of th Greco-Bactrian world.

Garnet and turquoise necklace

The dead were buried in funerary thes of extraordinary richness. Al-ugh the cloth had long since disap-ared, the abundant ornamentation de it possible to reconstruct much of original dress. The existence of hems, eves, and so forth could be ascertained many cases by the position of the origi-ly attached ornaments—a complex d often frustrating labor. These orna-nts—plaques, beads, rosettes, and ban-s—along with the personal belongings the deceased that were placed in the aves, reveal the sumptuousness of the ssessions of the Kushan elite.

The Golden Hoard of Bactria is a mag-ficent presentation of these mortuary ds, which have changed the name of the e from Tillya Tepe to the Golden ound. Its 166 full-page color illustra-ns; its definitive catalog of the finds, il-strated by black-and-white photo-aphs; and its running narrative of the cavation make this volume one of the chest art tomes I have seen.

The art styles reflect the many tradi-ns of central Asia. Indian, Greek, Ira-an, and Chinese motifs are readily per-ptible, but perhaps most interesting is e influence of the animal art style of the astoral nomads of central Asia. This style as found much earlier in the Scythian, unnish, and other cultures that once ominated the heart of Asia. As Sarianidi roperly points out, the infusion of this astoral style gives life to an art that was st becoming static, as the hybrid tradi-ons from which it derived lost their vigor. n some cases, the plethora of gold, silver, nd inlaid semiprecious stones cannot dis-uise some crudeness of execution and atness of expression, characteristic of ose periods of aesthetic history in which he demonstration of wealth takes prece-ence over taste and creativity. However, turn of the page belies these thoughts nd reveals a near masterpiece.

An estimated twenty thousand objects vere recovered at the Golden Mound—the naterial and aesthetic expression of a pe-iod in central Asian history that still re-nains somewhat of a mystery to us, for we know little of the culture that motivated his wealth. But this wonderful book in-vites speculation about a vanished way of ife and about a region of the world that is now closed, alas, to western travelers.

Walter A. Fairservis, Jr., is a research associate in the Department of Anthropology at the American Museum and professor of anthropology at Vassar College. He was director of the First and Second Afghan Expeditions for the American Museum.

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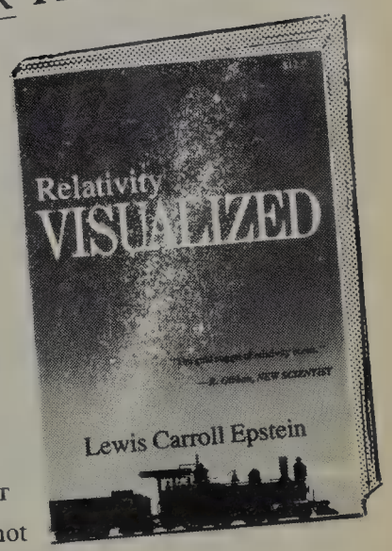

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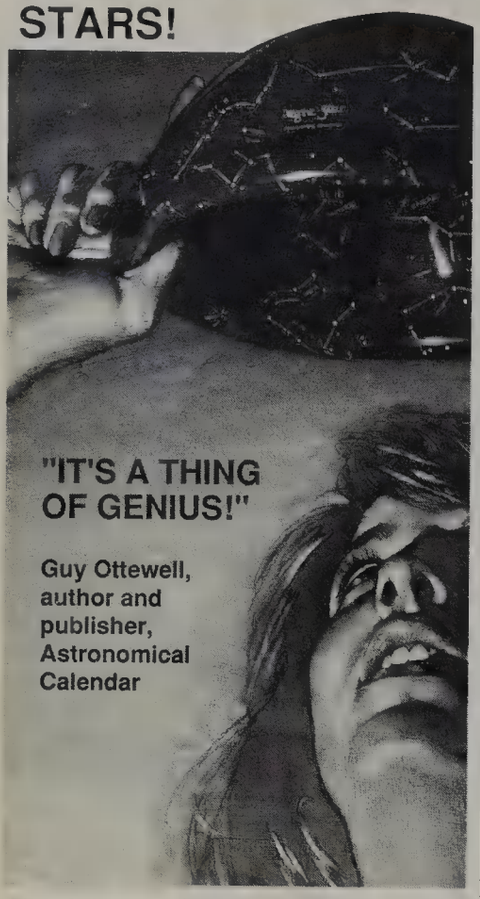

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Early to Rise

by Thomas D. Nicholson

Four planets are in the morning sky this month but none can be easily seen. Three (Mercury, Venus, and Saturn) are too near the sun, rising in the morning twilight and transiting the sky mostly in daylight. The fourth, Mars, rises about 2:30 A.M. Although quite high in the southeast before dawn, Mars is still very far from the earth and thus very dim. Since conjunction with the sun last July, Mars has brightened by less than half a magnitude, remaining inconspicuous near Spica in Virgo. It will still be several months before the promise of the morning planets becomes a reality. And before that, even Jupiter will join them in relative obscurity.

For now, Jupiter remains an evening star, though reduced to only a few hours above the horizon in dark skies. These waning weeks of its evening cycle, however, are among the most interesting. Jupiter is very bright, outshining every star in the night sky. It appears in the dwindling twilight of the southwest on December nights, less than an hour after sundown, and remains in the sky for a while, glimmering in the fading sunlight. These circumstances also make one of the prettiest of all evening scenes: a slender crescent moon joining a bright planet. That takes place this month on the evenings of the 14th and 15th when the moon brackets Jupiter from one night to the next. Unfortunately, the moon doesn't move close enough to the planet to create the kind of scene that poets immortalize.

The following events are given in local time unless otherwise noted.

December 1: A waning gibbous moon is up at dusk, in Cancer, but virtually in line with Pollux and Castor, the twin stars of Gemini. Watch closely after dark and you should notice the moon drift slowly away from Pollux to the left (east).

December 2: Mars has been moving slowly to the east through Virgo since October, toward the constellation's brighte star Spica. It slips past Spica today, an should be visible just above the bright sta before dawn this morning. The plane moves into Libra late in the month.

December 3–4: The waning moon is i Leo, to the right of its brightest star, Regu lus, on the 3d, and to the left on the 4t Regulus and the circular group of sta above it make up a backward questio mark, forming the head and front half o the lion.

December 5: Last-quarter moon (4:0 A.M., EST) is still in Leo but near its hin quarters and tail (the triangle above an left of the moon). Venus passes Saturn (passed Mercury on the 3d) but the planet rise too late in the morning to be visible

December 6–8: The crescent moon is i Virgo when it rises each morning, and th bright star below it is Spica. It passes th star and Mars on the 8th.

December 8: The moon occults (covers Mars this morning. The event can be see over parts of North America. Mars disap pears behind the moon's bright limb whil the two are below the horizon, but th planet reappears after it rises along th east coast of the United States, about 4:1 A.M., EST. The time varies slightly with lo cation.

December 9: This morning is probably the last chance to see the waning crescen moon in the sunrise glow in Libra. Spica i above it.

December 10: The moon is at perige (nearest the earth).

December 11: The moon is new at 7:54 P.M., EST, only 24 hours after perigee The close-in moon primes both the time and the height of the spring tide, causing tomorrow morning's high tide to be higher and earlier than usual.

December 14: The second-best meteor shower of the year, the Geminids, is at maximum today. The early morning hours, when the sky is moonless, are the

Celestial Events

est time for viewing. You may see up to 0 meteors per hour after 1:00 A.M. on the 4th and 15th, but they are usually not as right as the meteors of that paragon of howers, the Perseids.

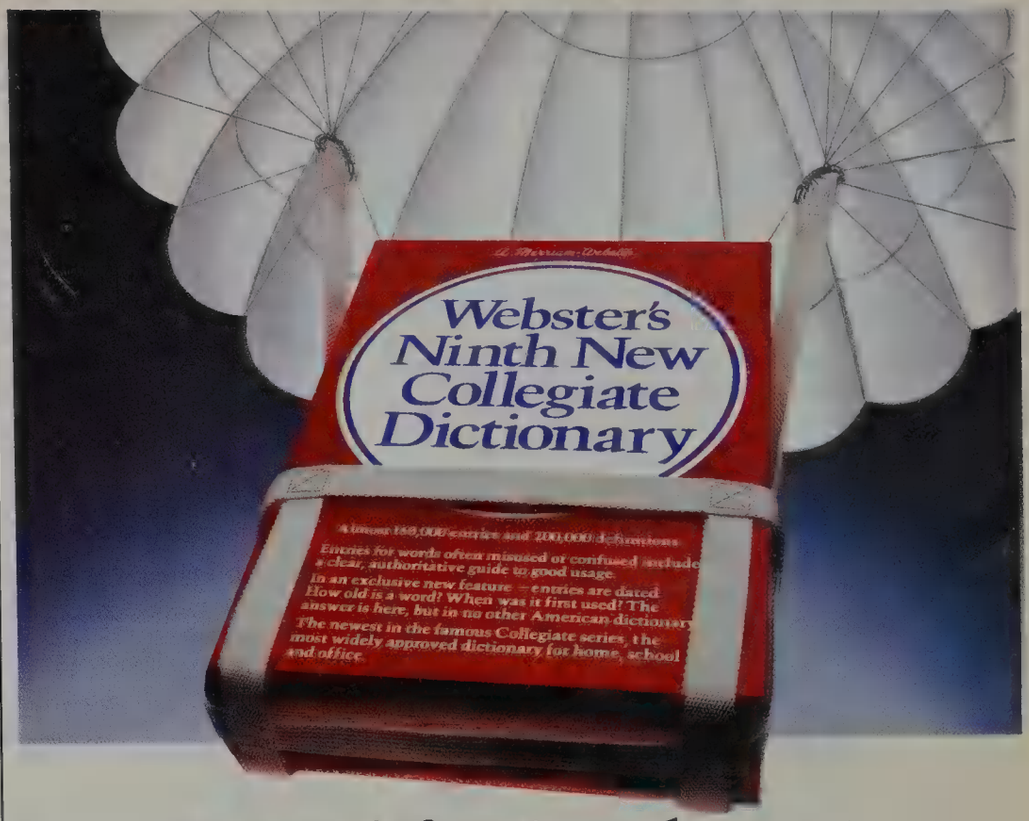
December 13–16: The chances of see-ng the thin, waxing moon are poor on the 3th, but good on the 14th. Night by ight, the moon appears higher in the eve-ing twilight and stays up later. It is below upiter until the 15th and then is higher han the planet.

December 16: Too bad we can't see Mercury and Saturn in the morning sky. Mercury passes Saturn, only a moon's di-ameter away, just about when it is at its greatest westerly elongation (to the sun's right). This morning, Mercury is actually brighter than Saturn and becomes even brighter during the rest of December. But celestial geometry is against us: the plan-ets rise too late in the morning twilight to make an appearance.

December 18: First-quarter moon (8:58 P.M., EST) is in Pisces. Because it has gone one-quarter of the way around the sun from the time of new moon, and the sun is at the winter solstice, we should see the moon near the vernal equinox. Indeed, the eastern edge of the Square of Pegasus is just above the moon tonight, and its two stars point downward very close to the ver-nal equinox.

December 21: The sun reaches the win-ter solstice, a point in Sagittarius along the ecliptic (the sun's apparent path through the stars) 23.5 degrees south of the equa-torial plane, at 5:08 P.M., EST, and the winter season begins in the Northern Hemisphere. The earliest sunset of the year occurred on December 8, however, and the latest sunrise will be on January 4.

December 22: The Ursid (named for Ursa Major) meteor shower is at maxi-mum with no moon in the morning. Not very productive (15 meteors per hour), but nonetheless something to see.



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December 23–25: Taurus is host to the fattening gibbous moon, moving out of Aries on the 23d, close to the Pleiades; swinging past the Hyades and Aldebaran on the 24th; and nestling between the Bull's horns on the 25th. On the 24th Jupiter makes a handsome Christmas star, low in the southwest at dusk. Too bad all that moonlight's there. It won't bother Jupiter, but it does add to the problems of finding Halley's comet, a dim, fuzzy object, without much of a tail yet, above Jupiter in Aquarius, just about on the equatorial plane.

December 27: Full moon (at 2:30 A.M., EST) in Gemini, above the twin stars (Pollux and Castor). Tomorrow night at the same hour, it rises with the twins, in line with them below Pollux, just about where it was at the beginning of December.

December 30–31: The moon is back in Leo again to end the month, rising well after sundown, riding up the eastern sky with the Lion in the late evening.

Halley's Comeback

Comet Halley entered the realm of the inner planets at the end of November when it moved inside the orbital distance of Mars, about 140 million miles from the sun. It moves out again when it passes the orbit of Mars in late April 1986, on its way out of the inner solar system. Our opportunity to see it is limited to that interval. What are our chances?

If we consider all the possibilities that can result from the way in which the orbits of the comet and the earth interact, they are not very good. As a matter of fact, they couldn't be worse. If we had to pick just one of Comet Halley's 29 known returns to see, we certainly chose a bad one. From all accounts, the visit of A.D. 837 was the best. The comet then passed within 4 million miles of the earth, displayed a tail that must have stretched halfway across the sky, and had a coma that was probably bright enough to be seen in daylight—and certainly in twilight.

The visit in 1910 was also one of the good ones, even though the earth didn't come nearly as close as it did in 837 and on other visits. However, the comet was *much* closer to the sun when earth passed by in 1910, and that can add a great deal to its appearance. I'm afraid that the written and oral tradition (and the photos) remaining from that relatively recent event have built up expectations that the 1985/86 event cannot possibly realize. Nevertheless, no matter how unfavorable things may be, this is our one shot at Comet Halley, the only chance most of us will have of seeing it. The following guide summarizes what these chances may be over the next five months.

December 1985: Comet Halley is a binocular object in good position for viewing in the evening sky from the Northern Hemisphere. Moving through Pisces, south of Pegasus (see map), it should be very easy to locate in relation to the bright stars of Pegasus above it, from dusk until it sets at least several hours later. Early December is best; the brightening moon shows up during the latter part of the month. The comet resembles a fuzzy star, drifting slowly to the right in the field of stars around it, with little or no evidence of a tail. After the middle of December, the moon (full on the 27th) will interfere with viewing.

January 1986: The best opportunity for Northern Hemisphere viewers will be in the first two weeks. The comet is low in the southeast at dusk, setting within a few hours, but there will be no moonlight in the early evening hours until mid-month. The comet is brighter than it was in December, technically bright enough for naked-eye viewing under ideal conditions, but binoculars are probably necessary in most circumstances. It brightens slowly during January, but after mid-month it is too low at sunset and sets before dark. In any case, light from the waxing moon will interfere after the 10th or 12th.

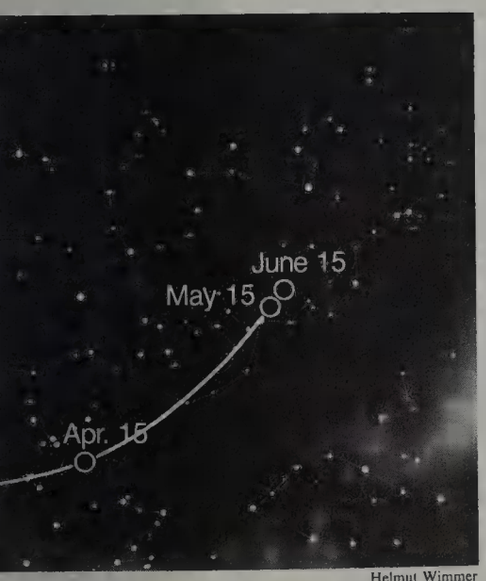
February 1986: The comet is lost from view all month because it is virtually in the same direction as the sun, above the horizon only in twilight and daylight. On February 9 it passes nearest to the sun (perihelion), about 54 million miles distant. Toward the end of the month it comes up in the east at just about dawn for Southern Hemisphere viewers; it is at its brightest and has its longest tail, but it is too low to be seen easily before the sky brightens.

March 1986: The view of Comet Halley's tail should be at its best. But everything favors southerly viewing locations. The comet is now well south of the equatorial plane and moving southward. It is a morning object, coming up before dawn. Toward the end of the month it moves through the easily recognized stars of Sagittarius, and mornings will be dark until the full moon approaches on the 26th. At latitude 40° north, there is virtually no chance of seeing the comet before morning twilight brightens the sky, but conditions improve farther south. It is definitely

th looking for from latitude 30° north
l southward. Below the equator it
uld be possible to see the comet's tail in
morning sky, a dim cloud of brightness
nting downward toward the east from
early morning hours until daybreak.

April 1986: The closest approach of the
rth to the comet on April 11 (39 million
les) gives us the brightest view in dark
urs, and morning skies are again dark.
then the tail will probably have shrunk
d the comet will have dimmed as its dis-
nce from the sun increases. It is strictly a
uthern sky object, too low for anyone
ove latitude 20° north to see but offer-
g Southern Hemisphere viewers the best
portunity of the whole show from about
pril 1 until the 15th. After that, the
met quickly swings into the evening sky
it slips between the earth and the sun.
hen it emerges in late April to the sun's
ft, it will be moving away rapidly, dim-
ing and shrinking again. But it is moving
rth again as well, giving northern view-
s with binoculars another shot at the
met as it fades.

May 1986: If you haven't seen Comet
alley by now, you will probably have to
ait until A.D. 2061. The view will proba-
y be better then.



Helmut Wimmer

The diagram, above, traces Halley's ath from left to right as it moves across he sky. The circles and dates indicate here the comet will be on the fifteenth of ach month until June 1986, when it will ave completed its journey around the un. The comet will continue to fade from iew, returning to interplanetary space.

The enlargement at right gives the ex- ct dates for the comet's positions as it asses through the stars of Pegasus and Aquarius. This map will be updated each nonth to let you know where Halley's omet will appear.

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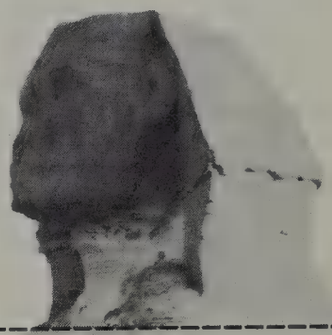

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Leon Sinks, Florida

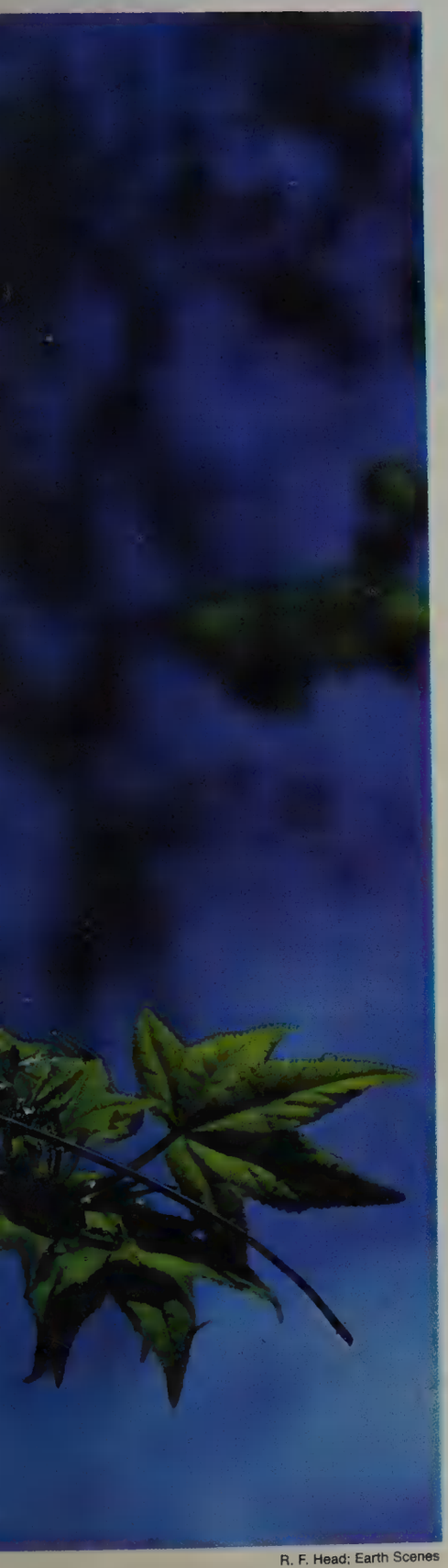
by Robert H. Mohlenbrock

The low hills of sandy, red clay that surround Tallahassee, Florida, drop off to the delta plains a few miles south of the city. To the casual observer, the plains, which slope gently for almost twenty miles to the Gulf of Mexico, seem a monotonous sea of sand that supports large numbers of longleaf pines and little else. But there are some surprises beneath the surface. Under the loose quartz sands is a bed of easily dissolved limestone. The abundant rains that fall in this humid, subtropical region (an average of fifty-seven inches annually) trickle through the permeable sands into this underlying layer. Percolating ground water dissolves the limestone, rapidly lowering parts of the terrain. The resultant depressions, or sinks, pock the landscape. Shallower sinks are filled with sand, but deeper ones often accumulate water.

A cluster of water-filled sinks perforate the sandy plains in the Apalachicola National Forest at the southern edge of Leon County and are known collectively as the Leon Sinks. A circular route that follows an old sand road for about a mile and a half passes by the five major sinks in the Leon Sinks Geological Area. Each sink has its own distinctive feature. Hammock Sink is a large, circular depression that drops sixty-five feet from the surrounding pinelands. Its basin, filled with clear, turquoise blue water, reflects the silhouettes of some of the surrounding trees. Black Sink is a funnel-shaped depression that drops into a deep, dark abyss. Gopher Sink, a cavernous hole lined with rocks, takes its name from its vague resemblance to a den inhabited by gopher tortoises. Natural Bridge Sink includes a tree-covered limestone bridge. Fisher Creek runs beneath the bridge and disappears underground, only to resurface 150 feet away.

Dismal Sink is the most impressive of the Leon Sinks. Two hundred feet from rim to rim, it drops abruptly seventy-five feet to a dark pool of unknown depth. For twenty feet above the water surface, the sheer, dripping walls are of solid rock. Handsome ferns, whose roots somehow have found narrow crevices in the rock,

Sweet gum is a southern hardwood species.



R. F. Head; Earth Scenes

display their feathery fronds above the water. There is no safe way to descend into Dismal Sink, and extreme care should be taken even when walking near its rim.

The abundant water in the sinks nourishes a community of plants that contrasts with the surrounding drier pinelands. Where the steep slopes of the sink are permanently moist, large specimens of laurel oak, water oak, white oak, southern magnolia, sweet gum, American beech, basswood, sweet bay, and sour gum may be found. On somewhat drier slopes, the dominant trees are mockernut and pignut hickories, red oak, and persimmon. These species, known collectively as southern mixed hardwoods, are found over much of the southeastern United States but are unexpected in the sandy coastal plains of Florida's Panhandle. Beneath the hardwoods is a layer of shrubs that consists of two gnarled members of the heath family, farkleberry and squaw huckleberry; a yellow-flowered shrub known as horse sugar; and small, symmetrical dogwoods. An entanglement of creepers often makes hiking difficult, while at ground level are wildflowers not found in the sandy surroundings.

The hike from one sink to the next takes the visitor through a different world of sand and sand-tolerant species. The relatively nonorganic, unconsolidated quartz sand primarily supports a sparse forest of longleaf pine and blackjack and turkey oaks. The pines may approach one hundred feet in height, but the oaks grow more slowly and seldom reach twenty feet. The herbaceous undergrowth is sparse, and large patches of sand remain exposed to the sun. Colonies of bracken fern, which can prosper under adverse conditions, give a false hope that the sand community can support lush vegetation.

Longleaf pine, whose mature needles are up to fifteen inches long, is well adapted to grow in the often deep sand of the coastal plain. It is found from North Carolina, around peninsular Florida, and over to eastern Texas, skipping only the Florida Keys, the Everglades, and the bottomland woods adjacent to the Mississippi River. For the first six years of its life, while its roots are developing, the young longleaf pine looks like a mounded clump of bright green grass. Its main bud remains level with the ground, where it forms long needles in dense clusters. When the little tree is about seven years old, however, it loses its grasslike appearance and begins a rapid upward growth, which continues until the tree begins to decline in vigor after three or four hundred years. Under optimal growing conditions, a longleaf pine may attain a height of 120 feet and have a trunk diameter of nearly 3 feet.

Because it cannot tolerate shade, the longleaf pine does not withstand competition from other trees, including others of its kind. The roots of a mature longleaf pine radiate for a distance of fifty to one hundred feet beneath the tree, and seedling longleaf pines that germinate within this radius survive only a short time. As a result, trees in a stand of longleaf pines are widely spaced. Considerable sunlight penetrates to the sandy ground between the trees, providing an ideal situation for the growth of wiregrass.

Fred Whitehead; Earth Scenes

A longleaf pine germinates.

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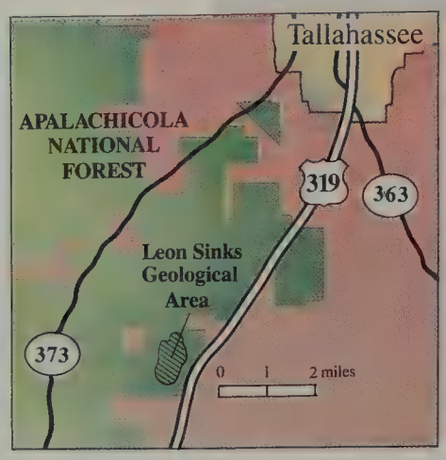

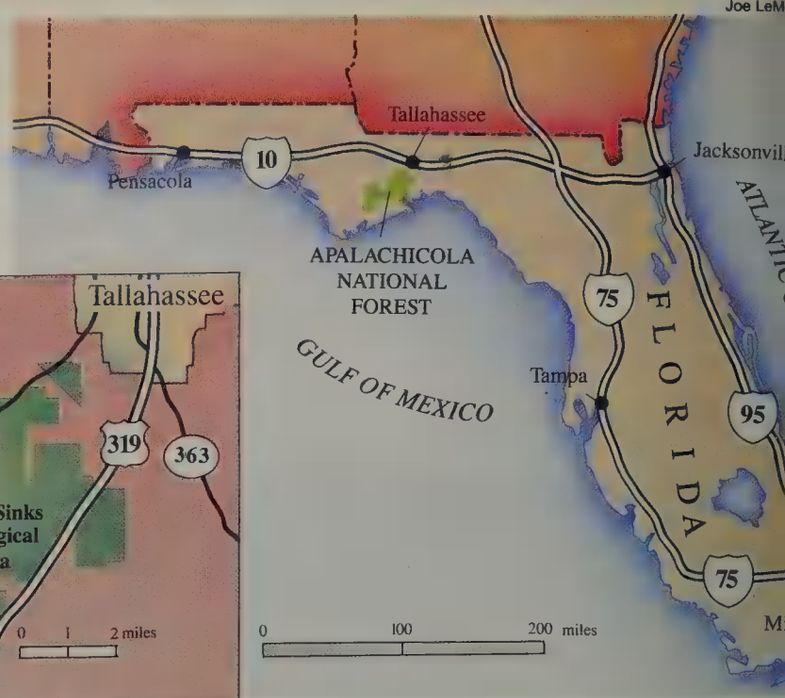

Leon Sinks

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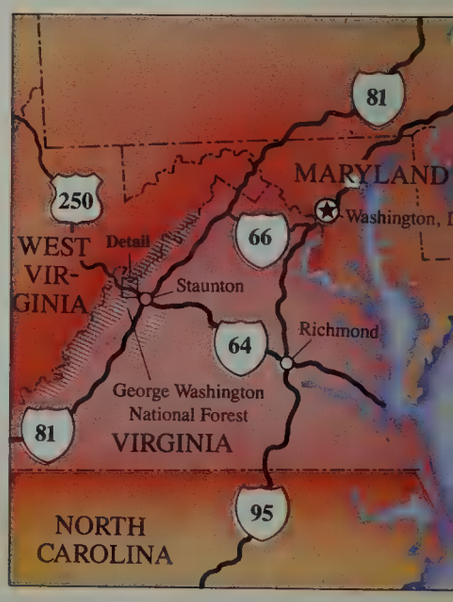
The wiregrass and the millions of pine needles that fall to the sand provide rapid-burning fuel for surface fires. Lightning frequently ignites such fires, which burn over wide areas of the pine community. One reason for the longleaf pine's success is that it is the most fire-resistant tree in the eastern United States. In the early growth stage, the dense cluster of needles protects the terminal bud from fire damage. Once the thick, flaky bark has formed on the trunk, the tree resists hot fires as if it had a covering of asbestos. In an experiment at Florida State University, a slab of bark from a mature longleaf pine was exposed to an acetylene torch for one minute. A thermometer placed on the side away from the flame registered only a three degree rise in temperature, and there was little damage to the bark.

The branches of the longleaf pine, unlike those of many other pines, are widely spaced, often giving the tree an appearance of spindliness. If the lower branches of a longleaf pine should ignite, the fire usually cannot advance to the branches above. The wide separation of the trees makes it unlikely that fire could spread from the crown of one tree to another.

The success of the longleaf pine actually depends on fire because periodic fires kill young saplings of other trees that might eventually provide competition. In addition, longleaf pine cones fall to the sandy ground unopened, and only a s ing fire will cause them to open. In way, seeds are liberated under the most vorable conditions. The tree's depende on fire was suggested as early as 1847 the British geologist Sir Charles Ly who observed this species on a visit to A bama. Several ecologists believe tha fire were kept out of a longleaf pine st long enough, many of the trees that r only line the limestone sinks would ger nate there and eventually choke out shade-intolerant pines, ultimately form a continuous community of south mixed hardwood species.

"This Land" highlights the biologi phenomena of the 153 U.S. national f ests. Robert H. Mohlenbrock is dis guished professor of botany at South Illinois University at Carbondale.



ERRATUM: In the map accompanying Nov ember's "This Land," some highways wer wrongly labeled. They are corrected abov

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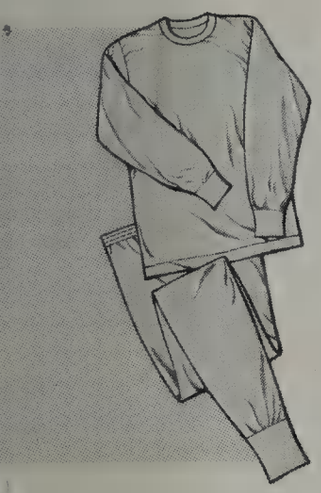

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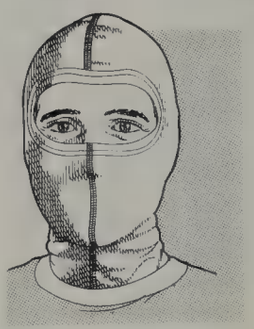

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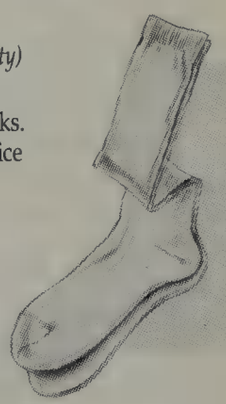

Sock Sizes	XS	S	M	L	XL
Men's Shoe	7	8	9-10	10½-11½	12-13
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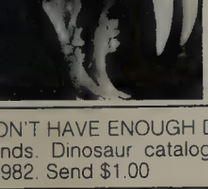

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Brontosaurus's Asian Cousin

On the cavernous second floor of the iseum's Roosevelt Rotunda are casts of o dinosaurs, put on display this past Oc- er. One, known as *Mamenchisaurus,* is enty-two feet long and eleven and one- f feet high at the shoulders. Its neck, rty-five feet in length, is the longest of y dinosaur ever discovered. It must ve weighed fifty tons when alive. The ier, a duck-billed dinosaur known as *intaosaurus,* stands eighteen feet tall d stretches twenty-three feet from the of its duck bill to the end of its tail. eager compared with *Mamenchisau- s, Tsintaosaurus* probably weighed out three tons. Both are the only exam- es of their kind, and are two of the most portant dinosaur skeletons ever found China.

A petroleum exploration team discov- ed the *Mamenchisaurus* in 1957 at amenchi, in Sichuan Province, western hina. The nearly complete skeleton (only e tip of its tail is missing) was excavated the Sichuan Provincial Museum, and e bones were taken to the Institute of ertebrate Paleontology and Paleoanthro- logy in Beijing. There they were care- lly chiseled from their rocky matrix, and e skeleton was then mounted for perma- nt display.

The *Mamenchisaurus* had been identi- ed and named as early as 1954 by Dr. hung-Chien Young, who is known as the ther of Chinese paleontology. Basing his ndings on the isolated bones of several in- viduals, Dr. Young had determined that *Iamenchisaurus* was a distinct species of uropod, giant plant-eating dinosaurs at flourished during the Upper Jurassic eriod (155–140 million years ago), when nosaurs were the dominant animals on nd. This new skeleton, though, was the rst—and subsequently the only—*Ma- enchisaurus* complete enough to be ounted.

A field party from the Institute of Pa- ontology discovered the *Tsintaosaurus* 1951, in Tsintao, Shandong Province, ong the eastern Chinese coast. The skel- on, also extraordinarily complete, was ken back to Beijing, where it was named nd prepared for exhibit by Dr. Young in 958. The *Tsintaosaurus* skeleton repre- sented another distinct species, a duck- billed dinosaur, or hadrosaur, that lived during the Upper Cretaceous period (95–65 million years ago), immediately preceding the extinction of the dinosaurs.

Until early in this decade, these dinosaurs were known to the West only through illustrations and scientific papers published by Dr. Young. But following the normalization of diplomatic relations between China and the United States in 1979, scientific contacts with Western-bloc nations increased, and in 1982 arrangements were made to bring these skeletons to Australia for a special exhibit.

As part of the exchange agreement, the Australians agreed to make polyurethane replicas of the dinosaur skeletons. Because the cost of prospecting for new dinosaurs is so high, and the chances of finding

Mamenchisaurus *is installed in the Rotunda.*

any specific species are so low, replicas of existing specimens are often made by one institution for another. The completeness of the *Mamenchisaurus* and the *Tsintaosaurus* made them excellent subjects. The work was done at the National Museum of Victoria in Melbourne, where a display hall was closed and converted to a workshop. Under the combined supervision of the museum's preparators and vertebrate paleontologists, rubber and plastic molds were made of each bone, and the polyurethane poured into these molds. Once the polyurethane hardened, the new "bone" was removed and colored to make it indistinguishable from the original. The process took several days for each bone, and more than three months for an entire skeleton. (Both *Mamenchisaurus* and *Tsintaosaurus* are composed of more than two hundred bones.)

Four casts were made of each of the two dinosaurs. One set was returned to China with the skeletons, and the second was kept by the Australians. The last two sets were offered for sale to the American Museum of Natural History and the Los Angeles County Museum of Natural History, at a price of $100,000 per set. The Los Angeles museum, which at the time was preparing a new dinosaur hall, bought one set, and the American Museum entered into negotiations for the other. In the meantime, the American Museum has borrowed Los Angeles's casts and has deferred a final decision on purchasing a set of its own.

If the American Museum decides to buy the two casts, they will join the world's largest collection of dinosaurs, one that is being continually expanded. The collection includes several skeletons found in North America that are relatives of the Chinese finds. During the time of the dinosaurs, the earth's present continents were connected in one great land mass known as Pangaea. The climate across this supercontinent was almost uniformly tropical and subtropical. The parallel conditions evidently caused the dinosaurs to coevolve, and related species are often discovered in areas now separated by oceans and thousand of miles of land.

Mamenchisaurus was closely related to and resembled the Museum's own *Brontosaurus* (more correctly called *Apatosaurus*), on display in the center of the Hall of Early Dinosaurs. *Mamenchisaurus* probably behaved much like *Brontosaurus*. It walked on all fours, and probably waded through the ponds of its swampy environment, either to keep its enormous body cool or to relieve it of the strain of its tremendous weight. Its cranelike neck may have enabled it to reach for soft leaves at the tops of giant fern trees, but this particular sauropod seems less suited than others to this mode of foraging. In many sauropods, the neck meets the body at an angle, facilitating its reaching ability. In the *Mamenchisaurus*, a rather rigidly constructed neck extends almost horizontally from the body, implying a certain lack of flexibility.

Tsintaosaurus, which lived some sixty million years later, was related to the numerous duck-billed dinosaurs that fill the Museum's Hall of Late Dinosaurs. The hadrosaurs probably also lived near water, and standing erect on their hind legs, they used their duck bills and four, clawed fingers to collect pine needles, cycad fronds, and any other available plant material. Besides ducklike bills, projections atop skull, in the shape of spikes, ridges, or low crests, characterize the hadrosa On *Tsintaosaurus*, this projection is a gle bony spike pointed forward. The sp may have been a weapon, a sexual disp or perhaps, covered with flesh when dinosaur was alive, a resonating cham allowing *Tsintaosaurus* to fill the la scape of late Cretaceous China with de sonorous tones.

The *Mamenchisaurus* and *Tsintaos rus* replicas will be on display in the M seum until January 6. Then they wil dismantled, packed in crates, and ship to Los Angeles, where they will be pla on permanent display.

Marshall Schwartz

At the American Museum

Seasons in the Sky

As live baroque music fills the Hayden Planetarium's Sky Theater, crystal-clear night skies, laser effects, and images of the seasons will flash upon the dome. *The Four Seasons*, on Wednesday, December 11, at 7:00 and 9:00 P.M., will feature Bach's Concerto no. 5 in F Major and Vivaldi's *The Four Seasons*. Tickets are $6.00 for members, and $9.00 for nonmembers, and must be ordered in advance. For additional information call (212) 873-1327.

Native American Film Festival

The six films in this year's free festival focus on diverse aspects of Native American life, such as dance styles throughout North America, the Hopi-Navajo land dispute, indigenous rights, and Venezuelan Indians who live on the edge of a geographic and cultural frontier. The festival will be held on December 14, and begins at 10:15 A.M. with a screening of Alan Lomax's *Rhythm of the Earth*. The final film, Connie Poten and Pamela Robert's *Contrary Warriors: A Story of the Crow Tribe*, begins at 4:45 P.M. All films will be shown in the Kaufmann Theater. For additional information call (212) 873-1300, ext. 559.

Who Gives a Toot?

On Sunday, December 15, at 3:00 P.M. the Bloomingdale Chamber Orchestra will present a free musical concert designed to appeal to young people. The program will take place in the Kaufmann Theater and includes works by Alexander Bizet, Edvard Grieg, and others. A special feature is Joe Szerly as Tubby the Tuba. For additional i formation call (212) 873-1300, ext. 55

Kwanzaa

Kwanzaa is a unique Afro-America holiday dedicated to the African ance try of present-day black Americans. It celebrated from December 26 throug January 1. The Museum will pay tribu to Kwanzaa by celebrating Seed Da Elders Day, and Regeneration Day, December 28, 29, and 30, respectivel Free programs, cosponsored by the Ed cation Department and the New Yo Urban Coalition, will take place in se eral areas of the Museum. For detai call (212) 873-1300, ext. 514.

The Star of Christmas

This holiday Sky Show, at the Ha den Planetarium through January takes viewers back in time nearly 2,00 years to view the skies of the first Chris mas. The show explores astronomic and mythological mysteries such as th "star" that led the three wise men fro the East to Bethlehem. For time an ticket information call the Planetariu at (212) 873-8828.

Courses for Stargazers

The Hayden Planetarium's course begin in early January. Topics this se son include the mysteries of Halley comet, life beyond the earth, planetar weather, navigation, aviation, the sola system, and more. For a free brochur please call (212) 873-1300, ext. 206 write: American Museum-Hayden Pla etarium, 81st Street at Central Par West, New York, N. Y. 10024.

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Tofu or Not Tofu

Is it nobler to consume bean curd or to eat meat in a protein-deficient world?

by Raymond Sokolov

While most of us weren't watching, the soybean multiplied in the fields of the Corn Belt and became America's third cash crop after corn and marijuana. Indeed, this country now produces three-quarters of the world's supply of this Asian legume. This is all the more remarkable because the vast majority of Americans know nothing or almost nothing about soybeans.

The reason is brutally simple. By and large, soy products do not show up on our tables in a form easily identifiable as soy. In fact, some effort is usually made to disguise *Glycine max* as something else. This practice goes back at least as far as World War II, when soy-based margarine came on the market as an ersatz butter that had to fight for fair treatment in markets against stiff lobbying and discriminatory laws fomented by the dairy industry.

So the national soy crop grew quietly, but it grew. Oil pressed from soybeans crept anonymously onto shelves where corn and peanut oil had previously dominated—and it surpassed them in sales, although most consumers did not realize that they were opting for a soy product over more "American" salad oils and many still don't. They know, however, that the price of soy oil is attractive, even though they may continue to think that the main culinary use of soybeans is to produce exotic soy sauce, which actually is a fermented form of soy meal and a source of protein in Asian cuisines.

Protein is the key word in any informed discussion of soybeans. They are a spectacular source of protein, five times richer than corn. And their amino acid makeup is dazzlingly close to that of meat (unlike most grains or legumes, which have to be mixed or supplemented to insure the necessary amount of complete protein in a nonmeat diet). None of this valuable soy protein makes its way into soy oil. Very little of it, in any form, is eaten by people in this country. Instead, we feed it to animals and then eat them. To a vocal minority of intelligent and well-meaning folk, this is shocking. While the Third World totters from malnutrition and African children's hair turns red before they die from the protein deficiency called kwashiorkor, we cast mountains of soy protein before swine and other livestock.

I will not bore you with a recitation of the embarrassing inefficiencies and wastefulness of our meat-centered cuisine. For at least twenty years, we have all been exposed to the highly cogent arguments of ecological zealots, such as Frances Moore Lappe, who want to maximize world agricultural resources. They make the irrefragable point that soy and other vegetable protein sources are the frugal, sensible route to nutritional sufficiency for all human beings.

Unfortunately, logic has run up against the most dismal of obstacles, the human factor. On the one hand, it has proved very difficult to spread food, even surplus food, among hungry nations. Politics, economics, and the physical difficulties of distribution all work against the best impulses of agriculturally successful nations, of which we are the surpassing example.

Even when donated food does reach needy populations, it is often a mixed blessing. They have accustomed themselves over generations to other staples and do not take easily to what we send. Ethiopia is a tragic example of international food charity barking its shins against an ingrained local food preference. As I wrote in the September issue, it is requiring the force of a totalitarian regime to induce starving Ethiopians to eat donated sorghum instead of the vanishing grain called teff that is a linchpin of their culture.

No one in this culture should scoff at the Ethiopians for this apparently suici stance. Food preference is a deep-sea conviction, especially in a traditional ture. And we Americans, superfici quick to latch on to new food fads, h only to consider our collective lack of thusiasm for soy protein foods to sym thize with the culinary "recalcitrance" the Ethiopians.

If logic could prevail in such matt we would have long ago abandoned steak and burger for soybean curd. Th pure white, delicate little cakes, of called tofu (the Japanese form of th original Chinese name, *doufu*), are an most ideal protein source. They are che they are free of cholesterol, and they ar neutral in taste that they go with alm any other food or flavoring. What is mo they are widely available, not just health-food stores, but in supermark And an evangelical literature has spru up to educate a carnivorous and reacti ary populace in the mysteries of tofu.

This preaching has won an impress number of converts. *The Book of Tofu*, William Shurtless and Akiko Aoyagi (T Speed Press, Berkeley), had sold 340,0 copies when it went back to press in 19 according to information on its cover. T same authors have also written guides other soy products, the fermented flav ing miso, and the cultured Indones "soyfood" tempeh.

It is tofu, however, that enjoys the w est acceptance in American life, to point where a soy-based, ice cream a logue called Tofutti is now compet with yogurt. But so far as I can see, products in any identifiable form are likely to cure us of our addiction to spa ribs or even cornbread.

I say this while absolutely doting on tofu dishes I have come to know in C nese restaurants. Perhaps the greatest i Szechuan specialty called *mapo doufu*.

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this fiery preparation, mushrooms, ground meat, and water chestnuts, as well as the typical spices of Szechuan, all enliven the cool and modest medium of bean curd.

Bean curd cuisine in China is a large subject. There is deep-fried bean curd and fermented bean curd and bean curd sheets—all prepared with a multiplicity of sauces and garnishes.

Once you begin reading about bean curd, you wonder how you could ever have thought it was a limited and intrinsically boring food. Its possibilities have been exhaustively worked out over centuries, especially in Japan, and they are, in concept, as diverse and enticing as the European repertory for chicken.

Just opening *The Book of Tofu* at random, I have come across several pages of recipes for bean curd cut into pouches and stuffed with everything from salad to sophisticated mixtures of mushroom, bamboo shoots, noodles, and quail eggs. There is smoked tofu, tofu diced in soup or in sukiyaki, and on and on.

Each stage of the basic process of making tofu out of soybeans has generated entire categories of foods. The whole beans can be eaten after soaking and boiling, roasted, or ground into flour. But in tofu process, beans are soaked overn and then ground, usually with more wa A blender does an ideal job. This puré called *go* in Japanese. It is useless as a tein source unless cooked, because beans contain a substance that inhibits enzyme trypsin and thus prevents di tion of soy protein. When this mas brought to a boil, it separates into a w "milk" and a fibrous, sawdustlike stance called *okara*. In American hea food stores, you will find frozen *okara* ties and also various forms of soy m Seasonings and potato made the patti tried reasonably palatable. A carton "Soy Moo" was flavored with ho which was the only detectable flavo the drink.

In standard tofu making, the *okar* strained out of the milk. Then, very m as rennet or other curdling agents added to mammal milk in cheesemak to cause the curds to coagulate out of whey, the tofumaker stirs a salt or an a into soy milk. For the most part, gyps (calcium sulfate) or Epsom salts (mag

Spicy Bean Curd

(Slightly adapted from *Chinese Meatless Cooking*, by Stella Lau Fessler. Plume, 1981)

- 3 squares fresh soft bean curd
- 2 tablespoons oil
- 1 teaspoon minced ginger
- 3 tablespoons chopped scallion
- 1 tablespoon Szechuan hot bean paste
- 1 tablespoon soy sauce
- ½ teaspoon salt
- ½ teaspoon sugar
- ½ cup stock
- 1½ teaspoons cornstarch dissolved in 2 tablespoons water
- 1 teaspoon sesame oil
- ¼ teaspoon Szechuan peppercorn powder (see note)

1. Rinse bean curd and drain. Cut into 1-inch-square pieces.
2. Set a wok (or skillet) over high heat and add oil. When oil is hot (and gives off a wisp of smoke), stir in ginger and 2 tablespoons scallion and cook for 20 seconds. Add hot bean paste and bean curd. With a spatula, stir bean curd very gently.
3. Add soy sauce, salt, sugar, and stock and bring to a full boil. Thicken sauce with dissolved cornstarch, then add sesame oil and peppercorn powder.
4. Immediately transfer everything from the wok (or skillet) to a serving platter. Sprinkle with remaining scallion and serve.

Yield: Two to four servings, depending o other dishes

Note: To produce powder, toast 3 tabl spoons of whole Szechuan peppercorns a dry skillet over medium heat for about minutes. Grind with mortar and pestl then sift through a strainer.

Shira Ae

(Slightly adapted from *At Home with Japanese Cooking*, by Elizabeth Andoh Knopf, 1980)

This thick white dressing looks som thing like cottage cheese and, Mrs. Ando suggests, can be used to stuff tomatoes. will keep under refrigeration, covered, f a day or two.

- ½ bean curd cake (about 6 ounces)
- 1¼ teaspoons superfine sugar
- Pinch of salt
- Drop of soy sauce (preferably *us kuchi shoyu*)
- ½ teaspoon sake (rice wine)

1. Boil the bean curd in water to cover f 2 to 3 minutes and then drain it in cloth-lined colander. Gathering up th edges of the cloth to make a bag, twi and squeeze to wring out all exce moisture.
2. Mash the bean curd before seasonin it with the remaining ingredients.

Yield: Two-thirds of a cup

sulfate) are the solidifiers in modern

ıe solidifiers cause tofu curds to pre-
ate out of hot soy milk. The curds
like little white flecks in a sea of clear
ɔw whey. Aficionados try to use as lit-
ɔlidifier as possible in order to produce
most delicate curds.

ɔ make standard tofu, you then strain
the whey and let the curds drain in a
nder or perforated mold until they set-
nto a delicate white cake.

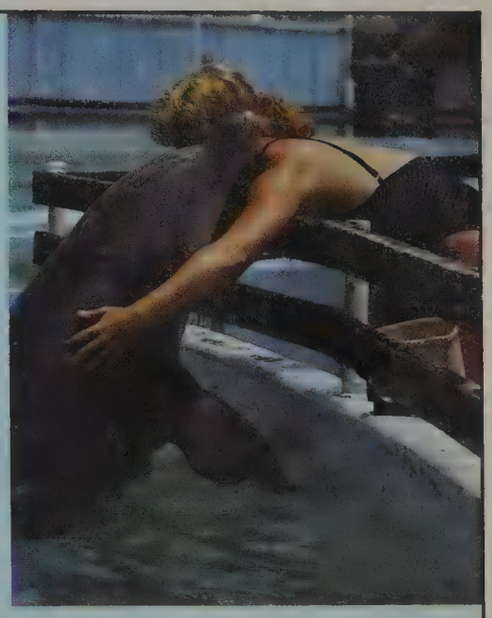
did all this, and I will say that it
ded a most delicate, soft tofu, better
ı I can buy even in oriental groceries.
tofu tasted just like all the earlier
ges in the process. It had no better fla-
than the milk or the *okara* or even the
ey. In other words, it tasted very bland,
ch blander than unsweetened oatmeal.
it did have a splendid texture. And ac-
ding to figures in *The Book of Tofu,* it
tained 73.5 percent of the original pro-
ı in the soybeans, in an attractive, com-
t cake that could be stored in water
te easily.

liked my tofu. I even ate some plain,
h moderate pleasure. But I liked the
a of it and the look of it much more
n I enjoyed it as a food in the mouth. At
t, I am willing to eat it only occasion-
in dishes that combine it with other,
orously flavored ingredients. No doubt
s means that I am hopelessly culture
ınd, a boor by Japanese standards, a
gish carnivore in a protein-poor world.
Frankly, I wouldn't have it any other
y. Food *is* culture bound, and aren't we
ky that it is. Our taste in food helps us
ine ourselves, helps make us feel at
me, and offers a ritual of familiar plea-
e in a world largely drained of ritual.
eat may be wasteful, but thrift and the
ional use of resources are not the only
tues in the world. The best policy in ag-
ulture is the one that attempts to supply
ople with as much of what they want as
humanly possible. A world resigned to
tting its protein from sensible, pure tofu
uld be a world that has given up on
easure as most people define pleasure.
en in Japan, young children think of
fu as something that is good for them,
e spinach for American children.

No one is ever going to persuade most
nericans that tofu can be more than an
casional diversion from normal food. A
end of mine, eager to try a new taste
eat, recently bit into a piece of deep-
ed tofu and said: "It's like French-fried
thing."

*aymond Sokolov is a writer with a spe-
al interest in the history and prepara-
on of food.*

PLEASE TOUCH



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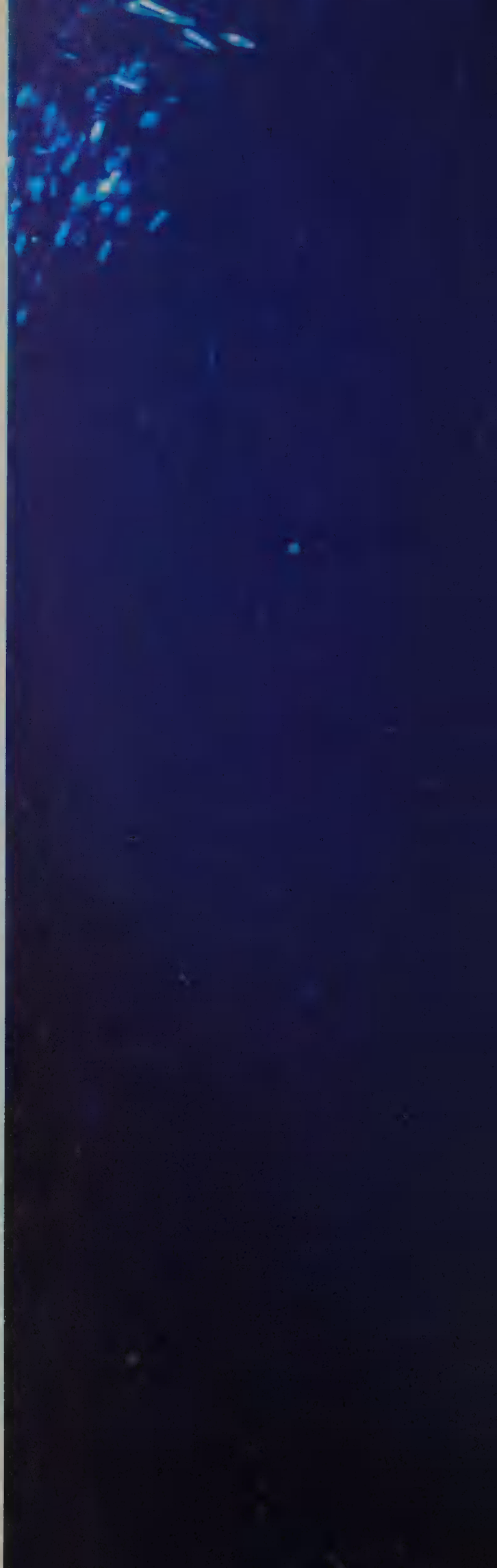
The southern tip of Baja California is the place people call Land's End and it's a pretty unceremonious ending. It's mostly rock: cliffs drop seventy feet to water and there's no beach to speak of. But below the surface the wall of rock continues, descending perhaps another sixty feet to the floor of the Sea of Cortez. This place, where the sea begins, is a lot livelier, at least from the photographer's point of view. Lots of sea lions paw around through the surf, and manta rays, big flat-headed creatures, frequently jet by. There are enormous schools of bait fish, and as naturalist-photographer Doc White learned one day last winter, there are cormorants down there too, taking the bait.

Cormorants, which are related to pelicans, anhingas, and other seaworthy birds of the order Pelecaniformes, fish for a living. They eat fish, crabs, squids, and some amphibian larvae. And they are excellent divers, partly because their bodies are well adapted to swimming underwater and their feathers are water permeable, which reduces buoyancy. Cormorants have been known to swallow stones to help themselves gain depth. In fact, cormorants are so good at fishing that people in some parts of Africa and Asia use them as hunters. They tie a collar around the bird's neck so that it can't swallow. Then they let it loose on a long leash, the bird dives, and when it surfaces, they take the fish out of its mouth.

Doc White was diving and photographing off Land's End when he noticed this cormorant tracking schools of fish. One thing that intrigued him about its technique was that the bird seemed to pick out one fish from the crowd and concentrate on it. White's impression was that this helped the bird avoid being distracted by the quick, glittery maneuverings of the larger mass of fish. Whenever it caught a fish, the cormorant swam up to the surface to eat it. A few minutes later, the photographer was rejoined by the hunter and the hunt continued.

Unlike a bird, a naturalist-photographer doesn't find out the results of a hunt right away, so it wasn't for another day or two that Doc White found out just what he had caught: a dark bird pointed at a fish cloud just beyond Land's End.

Photograph by Doc White



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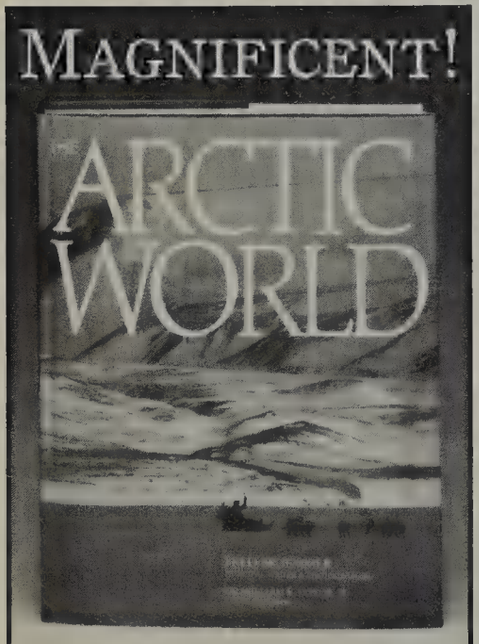

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Additional Reading

Burgess Shale (p. 34)

The Burgess Shale, by Harry B. Whittington (New Haven: Yale University Press, 1985), is a comprehensive and fully illustrated account of this great paleontological find. Whittington, a leading authority on the Shale's fauna, summarizes what is currently known about these ancient fossils: how they came to be so perfectly preserved, how new reconstructions of the animals have been made, and what their lives were like. "The Animals of the Burgess Shale," by Whittington and Simon Conway Morris (*Scientific American,* July 1979, pp. 122–33), describes the Burgess Shale fauna and reconstructs the underwater environment these organisms inhabited some 530 million years ago. Roger Lewin, a British science writer who has been associated with *New Scientist* and *Science,* is author of *Thread of Life* (Washington, D.C.: Smithsonian Books, 1982), an excellent introduction to evolution, sponsored by the Smithsonian Institution and with an introduction by Ernst Mayr. Aimed at the general public, it is easy to read and abundantly illustrated and noteworthy in this instance because it includes a good section on the Burgess Shale, "A Submarine Explosion of Forms" (pp. 106–25).

Babassu Palm (p. 40)

Two good introductions to the study of the babassu palm can be found in *Economic Botany,* a journal published by the New York Botanical Garden (Bronx, New York 10458-9980) for the Society for Economic Botany. They are "The Babassu Oil Palm of Brazil," by K.S. Markley (vol. 25, pp. 267–304), and "Subsistence Benefits from the Babassu Palm," by P.H. May et al. (vol. 39, pp. 113–29). *Harvest of the Palm,* by James J. Fox (Cambridge: Harvard University Press, 1977), discusses two islands in southeastern Indonesia with economies centered on the intensive use of the lontar palm tree. The palm's juice is the staple of the people's diet and its leaves, leafstalks, and trunks provide the wherewithal for their housing. Harol Moore, one of the world's foremost p taxonomists, contributed "Palms in Tropical Forest Ecosystems of Africa South America" to *Tropical Forest E systems in Africa and South Americ* comparative review edited by Meggers, E.S. Ayensu, and W.D. Du worth (Washington, D.C.: Smithso Institution Press, 1973).

Captive Images (p. 50)

The White Man's Indian, by Robe Berkhofer, Jr. (New York: Vintage Bo 1978), is a fascinating account of whites have stereotyped the American dian, beginning five centuries ago with lumbus's discovery of America and tinuing until today. Berkhofer shows early colonists quickly adopted a descending set of assumptions about tive peoples that pervaded almost all sequent thought about the Indian– philosophy, science, the arts, and lit ture, as well as in the policies of gov ment officials, missionaries, and soldi Richard Slotkin's *Regeneration Thro Violence* (Middletown, CT: Wesle University Press, 1973) is a literary an sis of the relations between American I ans and European-Americans from c nial times through the mid-ninetee century. Slotkin explores the approac the Indian in the writings of Co Mather, James Fenimore Cooper, other American authors, and traces the literary traditions developed f early narratives of war and captivity le the emergence of the frontier hero pers fied by Daniel Boone. *The Invasion America,* by Francis Jennings (New Y W.W. Norton and Co., 1975), a revisio history of Indian–white relations in se teenth-century colonial New England cludes a discussion of King Philip's W James L. Axtell's *The European and Indian* (Oxford: Oxford University Pr 1981), a series of essays on the intern tions of Indians and white colonists on Atlantic Seaboard, contains a numbe

ovocative articles about white captives. *ritans Among the Indians,* edited by den T. Vaughan and Edward W. Clark ambridge: Harvard University Press, 81), is a collection of actual Puritan otivity narratives, including Mary Rowdson's diary, dating to the first quarter the eighteenth century. The narratives e edited (with updated language) and notated with a good introduction. The ginal version of Rowlandson's narrative s published in a facsimile edition by rland Publishing, New York, in 1977: *e Narrative of North American Indian ptivity,* Vol. 1 (third edition), edited by ilcomb E. Washburn.

lward Lear (p. 58)

The first biography of Edward Lear s Angus Davidson's *Edward Lear: ndscape Painter and Nonsense Poet* 812–1888) (London: John Murray, 68). Among the many other books that al with Lear's life and work as a writer, ustrator, artist, musician, and traveler e: Philip Hofer's *Edward Lear* (New rk: Oxford University Press, 1962) and *dward Lear as a Landscape Draughtsan* (Cambridge: Belknap Press of Harrd University, 1967); E. Kelen's *Mr. onsense: A Life of Edward Lear* (Nashle: Thomas Nelson, 1973); John Lehann's *Edward Lear and His World* New York: Scribner's, 1977); Vivien oakes's *Edward Lear: The Life of a anderer* (London: BBC Publications, 85); S. Hyman's *Edward Lear's Birds* ondon: Weidenfeld and Nicolson, 80); and A. Thorpe's *The Birds of Edard Lear* (London: Ariel Press, 1975). ome of the well-known writers who have mmented on Lear include Aldous Huxy in *On the Margin* (London: Chatto and indus, 1923, pp. 167–72), George Orell in *Shooting an Elephant and Other ssays* (New York: Harcourt, Brace, 945, pp. 187–92), and Peter Quennell in *he Singular Preference* (London: Colns, 1952, pp. 95–101).

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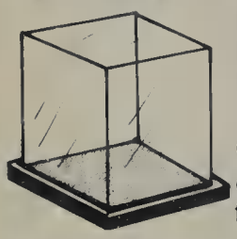
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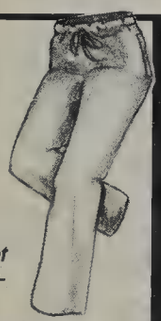
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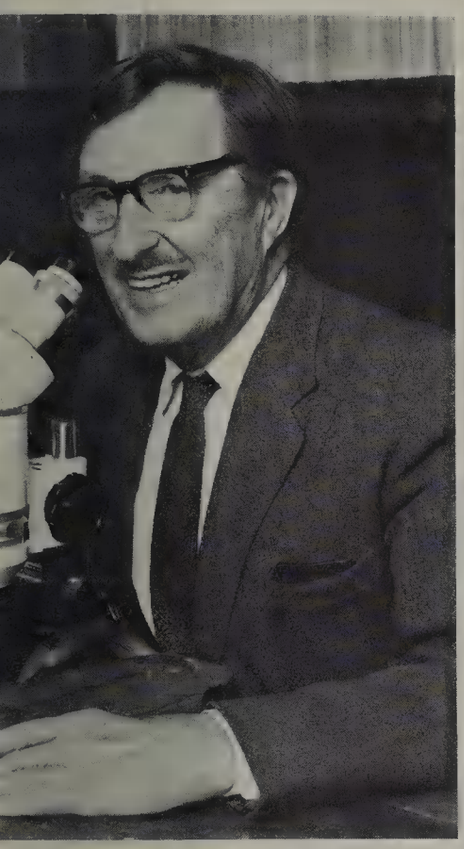
Authors

How do paleontologists reconstruct an ancient environment? To bring the Burgess Shale fossils of British Columbia to life, **Derek Briggs**, left, and **Harry Whittington** (page 34) needed the stamina of mountaineers, the exactitude of anatomists, and a blend of logic and imagination. Briggs, a lecturer in geology at the University of Bristol, England, says that the excitement of this work lies in "the discovery of animals unlike any others known, and the interpretation of their mode of life from first principles." The Burgess Shale was first investigated in the early 1900s. Coauthor Harry Whittington, who led the reinvestigation, is Emeritus Woodwardian Professor of Geology at the University of Cambridge, England. His fieldwork has been conducted virtually worldwide. Briggs, whose fieldwork has centered in the British Isles and North America, faces a new challenge: describing a group of fossilized, soft-bodied Silurian animals recently discovered in Wisconsin.



Anthony and Suely Anderson (page 0), husband and wife and coauthors, net on an airplane flight over the Ama- on River in 1975. "As recently as nine ears ago," they report, "one could fly ver vast stretches of the region and see nly a few clearings. This is no longer ossible." Their belief that "conserva- ion in this area ultimately depends on ational land management in already ettled places" led them to study ba- assu palm forests, the subject of their rticle in this issue of *Natural History*. Anthony, who earned a Ph. D. in botany t the University of Florida, has done eldwork in Central America, the An- ean countries, and eastern Amazonia. Suely has done fieldwork in both central nd eastern Amazonia. He comes origi- ally from Massachusetts; she comes rom São Paulo. With their two children, he Andersons now live in Belém, where Anthony is a researcher at the Goeldi Museum studying the Kayapo Indian ystem of forest management. Suely vorks as a translator.

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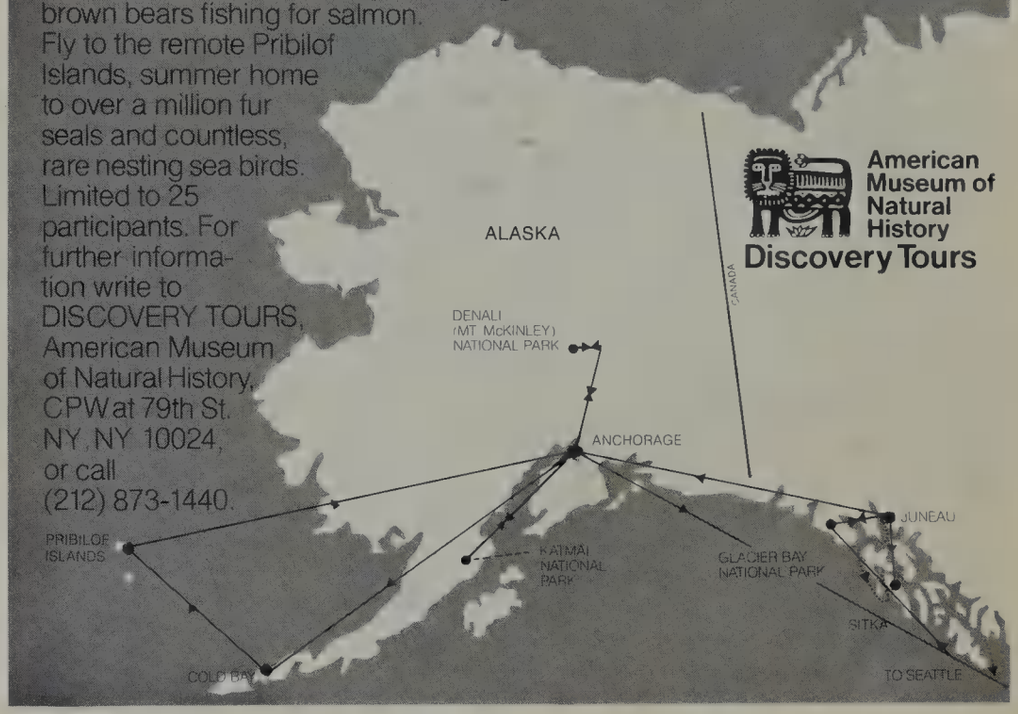

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Pauline Turner Strong (page 50) says her concern with the stereotyping of social groups dates back to her student days at inner city schools in the late 1960s—a time when the nation's conscience was aroused by racial discrimination. Her scholarly interest in the subject began after college, when she worked as a research assistant to Alfonso Ortiz, an anthropologist who was documenting how fixed notions about American Indians developed. Strong became especially intrigued with the way narratives written by early American colonists taken captive by Indians influenced the creation of these stereotypes. In 1977, when she began graduate work in anthropology at the University of Chicago, she decided to delve into this topic for her dissertation. Strong is currently an instructor of anthropology at Colorado College in Colorado Springs.

Vivien Noakes (page 58), a freelan writer who lives in London, has enjoye the works of Edward Lear since chil hood. In 1963, she began to study Le professionally and in 1968 she publishe *Edward Lear: The Life of a Wandere* now in its third edition. Considered t leading authority on Lear, Noakes w guest curator for the exhibition "Edwa Lear: 1812–1888" at the Royal Aca emy of Arts in London and The Nation Academy of Design in New York Cit She hopes next to turn her attention the First World War and is at present d ing research on that subject. Any tim left over from research projects is d voted to reading, music, and her famil

Doc White (page 90), whose firs name is really Shelton, specializes in u derwater photography. He began divin for fun in 1958 and was "utterl amazed" by what he saw. Those sight led him to begin spearfishing and tha led him to take up underwater photogra phy. When he is not diving himself, h runs a charter boat service for othe divers off the southern California coas The most important characteristic fo would-be underwater photographers White says, is to be a good diver and t get to know the environment. "You'v got to get there first" before you can tak a picture. The photograph published i this month's "The Natural Moment was taken with a Nikonos II camera an a 15-mm underwater Nikkor lens.